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Herbert A Smith  
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*Man forever will err; yet an innate longing desire  
Draws the aspiring mind gently toward the truth.*

GOETHE.

# LOCAL ANESTHESIA IN DENTISTRY

WITH SPECIAL REFERENCE TO INFILTRATION  
AND CONDUCTION

*A GUIDE FOR DENTISTS, ORAL SURGEONS AND STUDENTS*

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THIRD AMERICAN EDITION, THOROUGHLY REVISED

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## P R E F A C E.

THE prediction was made, when the second edition of this book was offered, that the methods propounded in its pages were "in a fair way to become routine practice." Private, clinical and military practice have fully confirmed the faith pronounced at that time and, today, conduction anesthesia with novocain-suprarenin solution is generally adopted.

The World War has convinced the progressive and the conservative alike that conduction anesthesia is an exact science and practice which proves its efficiency and reliability even under the most trying tests. As a matter of fact, without it, the wonderful facio-maxillary restorations which dental and oral surgeons of all nations performed during the War would have been well-nigh impossible. No comparatively new method has ever undergone a more severe test and proved so universally reliable.

Braun's technique as adopted for dentistry by Fischer has been subjected to various attempts at modification, none of which, however, have materially improved upon its efficacy or simplicity.

In view of the wider scope of application of conduction anesthesia in operative dentistry, exodontia and oral surgery, it has been deemed advisable to extend the text matter to include the methods of extra-oral injection.

A great portion of the previous subject-matter has been condensed, new text and illustrations added, and due consideration accorded to the literature of the past few years.

The publishers, Messrs. Lea & Febiger, have again spared no pains to make this book a worthy successor to its previous editions.

R. H. R.



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# LOCAL ANESTHESIA IN DENTISTRY.

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## PART I.

### MODERN LOCAL ANESTHETICS AND THEIR APPLICATIONS.

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#### PAIN.

FROM time immemorial the problem of the prevention of pain has engaged the attention of practitioners of the healing art, and among its branches surgery especially has striven to effect the elimination of that most serious handicap to its endeavors. To dentistry—which from a small scion of medicine has developed into an independent science—belongs the credit for having introduced the inestimable boon of what we know as “general anesthesia.” By their earnest coöperation general and dental surgery have obtained a remarkable perfection of local anesthesia and have greatly extended the range of application of this invaluable aid in their respective fields.

In dental operations, which are so extremely painful as compared with other operative interventions, the desire to diminish or to abolish the sensibility of the teeth is especially justified since the general enervation resulting from modern civilization is on an increase. Moreover, dental disease has assumed such alarming proportions that all possible means of inhibiting this universal scourge deserve serious consideration.

Pain is a phenomenon wisely instituted by Nature. To use Goldscheider's words: “Pain makes us realize that some external danger

is threatening which we may still avoid, or that harm has already been done to the body requiring our care if we would escape more serious consequences. Pain arises as a warning signal whenever we are exposed to such conditions of life as by their continued influence would involve general disturbances of health. Pain appears before or simultaneously with the outbreak of disease, warning man that his body is in a diseased condition and requires care. Pain occasioned by physical or mental fatigue indicates the necessity for rest and recreation. Pain, the symptom of organic disease, imperatively urges the patient to nurse the diseased organ. Pain is the physician's most powerful assistant, whose demands the patient follows in blind obedience, and who saves the physician many a prescription, many an advice as to diet and conduct. Through pain Nature imposes rest even upon the most strenuous; it dictates idleness to the most energetic, and forces the most obstinate to abide by conditions suitable for the diseased body.

"Pain is a harsh but useful law of Nature. But, like all natural laws, it is unyielding in its consistency, blind in its disregard, brutal and cruel. Pain appears not only in the guise of benevolent warning but also in that of troublesome torment. Even in incurable disease, in affections in which the realization of ill health is useless to the patient, inasmuch as it is beyond control, pain is present, ruthlessly destroying all enjoyment in life without offering any physical advantage whatever by way of compensation. In the most dangerous diseases pain is often absent, thus lulling the patient into a sense of security, only to appear and call for abolition by artificial means after the patient has undergone an operation in order to save his life. Hence it is only proper that we physicians should combat our ally. To wipe out pain entirely is an impossibility, and we cannot and would not do without it, since pain is necessary not only as a monitor in the combat against the hostile powers of matter but also as an inspirer to ethical emotions. For it is chiefly in the reminiscence of one's own pain, both physical and mental, that love and active charity are rooted."

Pain belongs to that order of phenomena which are usually termed conditions or general sensations, such as tickling, itching, hunger,

thirst, nausea, and others. They are all distinguished by a high degree of pleasurable or unpleasurable sensation, and do not inform us concerning our environment like the sensory perceptions, but above all attract our attention to the altered state of our own body.

Pain, empirically, can originate only within the radius of the centripetal sensory nerves and the nerves of touch, while the perceptions of other sensory nerves are perhaps disagreeable, but never really painful. Sensations of pain and touch, therefore, are different degrees of the same sensation; a light stimulus produces the sensation of touch or pressure, while a stimulus intensified beyond the maximum produces pain. Pain is caused by the increase of a stimulus beyond a certain limit; this stimulus radiates over neighboring nerve plexuses, and lasts provided the area acted upon possesses sufficient sensibility. Hence the intensity and the duration of a stimulus exert a decisive influence upon the character of an irritation. If the action of a stimulus is sufficiently prolonged, the sum total of the resulting irritation is probably stored in the sensory ganglionic cells, leading to a summation of individual stimulative impulses which produce the effect of pain, and at the same time a hyperalgesic condition. Inflammatory pain is probably due to a hyperalgesic condition of the ganglionic cells induced by the prolonged action of a stimulus.

The character of pain may vary considerably. According to Erb, burning pains may arise from an admixture of sense perceptions; pricking pains from localization or expansion; throbbing pains from change in the stimulative process. "The intensity of pain is greatly dependent upon psychic factors, and is the greater the more we abandon ourselves to it, while diversion and will power mitigate even exceedingly unpleasurable sensations. Kant, for instance, is said to have overcome the torture of gout by concentrating his thoughts upon a definite subject. At night, after the continually changing impressions of a day have ceased to occupy the mind, pain is felt all the more intensely." (Mangold.)

Other factors, such as education, character, intelligence, race, age, sex, and general health, exert a considerable influence upon the origin and manifestation of painful affections. Personal energy has a great

deal to do with preventing or mitigating pain, so much so that individuals endowed with strong will power can tolerate acute pain.

Pain, like all other sensations, is one of the functions of the cerebral cortex, in the "sphere of physical sensations" of which the sensory filaments are supposed to terminate. If the tract of fibers radiating from the cortical region is interrupted in the region between the posterior and anterior ends of the thalamus complete anesthesia of the opposite half of the body ensues. The peripheral sensory nerves of the brain and spinal column within the spinal cord, including the gray substance, are to be considered as conductors of painful sensations. The sympathetic nervous system, however, probably does not possess the faculty of conducting pain.

The end organs of the sensory nerves are tuned to certain forms of stimuli, and conduct these farther on to the cerebral cortex, probably in such a way that complicated chemical changes are transmitted from cell to cell.

Stimuli of different quality, *i. e.*, mechanical, chemical, thermal, and electric stimuli, are capable of producing painful sensations in the sensory end organs, or along their conducting tracts. A sensation of pain originating in the cerebral cortex is communicated to the parts of the body lying outside of the brain in such a manner that the pain is not clearly localized but vaguely circumscribed, as is frequently observed in the oral cavity. The irritability of diseased tissue is generally increased, rarely diminished. Acute inflammations in which the increase in blood-pressure plays an important role, tend to produce specially rapid and severe irritations of the sensory nerve plexuses involved, *i. e.*, hyperalgesia. On the other hand, local disturbances in nutrition, as, for instance, loss of function in dental pulps and chronic edemas, may produce a diminution of sensation, *i. e.*, hypalgesia.

Besides the varied distribution of the sensory nerve plexuses, the function and the situation of an organ bear an important relation to its irritability. When looking at pain as a defensive phenomenon, it is plain why the tissues closest to the surface, *i. e.*, the skin with its appendages possess greatest sensibility which progressively dimin-

ishes in the deeper lying organs. The skin exhibits numerous variations in sensibility. The fingers, the teeth, the mucous membranes are more sensitive than the extremities or the back. Muscles and tendons are insensible, but periosteum and marrow render bone as a whole most sensitive. For this reason subperiosteal injection is contraindicated, infiltration of the subcutaneous tissue layers taking its place. Of all skeletal units the teeth and their investing tissues are the most sensitive; the teeth, because they contain the purely sensory end-fibers of the second and third trigeminal branches, the pericementum and periosteum on account of their dense network of sensory nerve fibers which respond most painfully to the slightest disturbance. The mucous membranes exhibit a lesser degree of sensibility, but are extremely sensitive to reflexes and respond to touch upon certain areas with itching, gagging, retching or lachrimation.

From the beginnings of practical medicine this distribution of sensitive areas throughout the body has been carefully studied, and indefatigable efforts have been made to reduce the sensibility of the tissues by artificial means so as to render operative interventions possible. These efforts tend to produce either abolition of sensibility, *i. e.*, *anesthesia*, or at least inhibition of painful sensation, *i. e.*, *analgesia*. This condition of insensibility is sometimes brought about by Nature itself, when, for instance, normal irritability of the sensory nerves is reduced during profound sleep or in sickness; but it can be produced by artificial means, *i. e.*, by narcotics, such as chloroform, ether, etc.; by local anesthetics, such as cocain, novocain, etc., or by hypnosis.

### BRIEF HISTORICAL REVIEW.

Among all peoples and in all eras efforts have been made, more or less successfully, to discover means for the prevention of pain. It was, however, not so much local as general anesthesia which at first appeared desirable, and various agents, especially vegetable extracts, were administered for that purpose. Narcotizing decoctions, such as the mandrake root potion, were frequently given in order to produce a sleep-like state, during which operative interventions could be carried out.

In the year 50 A.D. Dioscorides is said to have made the first attempt to produce a sort of anesthesia by pulverizing the Memphis stone, mixing it with vinegar into a paste, and allowing it to act locally upon the skin for some time before an operation. In this preparation carbonic acid presumably played some role, being liberated in the mixture of limestone and vinegar, and producing cold, thereby effecting a slight anesthesia in the skin area thus treated.

In the Middle Ages local anesthesia seems to have fallen into oblivion, for it was not until the end of the eighteenth century that James Moore suggested that by compressing nerve trunks, or by severing them, analgesic areas could be produced. Owing to the numerous anastomoses of nerves, the application of Moore's procedure naturally was but a limited one, and the efforts of the investigators of that time were therefore directed to perfecting the methods of general anesthesia.

It was in 1866 that local anesthesia began to receive its due recognition. This was brought about by comparatively successful attempts of Richardson to obtain anesthesia of the skin by means of the ether spray, the application of which, in a limited degree, is considered correct practice to this day. Richardson, who did pioneer work also in the field of general anesthesia, is entitled to special credit in regard to local anesthesia, for he drew attention to the great value of this method, and succeeded in interesting the surgeons of the day in his ideas.

About the seventies of the last century local anesthesia lay dormant until it was awakened into new life by the efforts of Koller, Schleich, Robson, Corning, Oberst, and others. At the Congress of Ophthalmologists held in Heidelberg, in 1884, Koller demonstrated the remarkable anesthetizing power of cocain, which, after its action had been hurriedly tested by many authorities, quickly sprang into general popularity. But the methods of application of this drug were not sufficiently tested, and consequently, especially in anesthesia of the mucous membrane, fatalities frequently occurred owing to the toxicity of cocain, until Schleich and Reclus introduced their method of infiltration anesthesia by means of comparatively very small cocain

doses. This method was still further perfected when Braun recommended the admixture of extract of the suprarenal capsule to the anesthetic solution.

Conduction anesthesia (perineural or regional anesthesia), which is used so successfully today, was first suggested by Halsted, of Baltimore, in 1885. Instead of injecting cocain in the vicinity of the tooth to be anesthetized, he injected it near the trunk of the inferior dental nerve. This principle of perineural injection was applied by Kummer and Pernice in anesthesia of toes and fingers.

*Medullary anesthesia*, which also is very popular today, and which has been perfected by Bier, was known as early as 1885 to Corning, who discovered by animal experiments that the lower extremities became insensible after anesthetization of the spinal cord by injection between the spinous processes of the lumbar vertebræ.

Many investigators, such as Schleich, von Mikulicz, Braun, Kocher, and von Eiselsberg, who have materially contributed to the progress made in this field, have specially sought to do away with the toxic effects of cocain on the heart and the central nervous system which must be reckoned with, despite its high anesthetizing power.

Substitutes were offered, such as eucain alpha and beta (Silex), acoïn (von Heyden), holocain (Täuber), tropacocain (Giesel), orthoform, nirvanin (Einhorn and Heinz), anesthesin and subcutin (Ritsert), stovain (Fourneau), alypin, novocain (Einhorn), and others. All these drugs were supposed to possess the anesthetizing power of cocain without its toxicity. Science and industry made unceasing efforts to find an ideal preparation for the purpose of local anesthesia. It was Braun especially who tried to compare the different cocain substitutes in regard to their specific action. He showed that anesthesia is a chemical process, a combination of the anesthetic with the cell elements, *i. e.*, the nerves of the injected area. Contrary to Schleich, he considered the physical factors, such as cooling, difference in osmotic pressure, and direct pressure upon the nerves, as non-essential. Above all, he emphasized that the simultaneous contraction of the blood-vessels in an injected area is an important aid in the profundity and duration of the anesthesia. For this reason he advised combining

suprarenal preparations with anesthetics, and this combination has now become absolutely indispensable.

Local anesthesia by injection has become a common practice in dentistry, owing to the noteworthy work of researchers and practitioners on both sides of the Atlantic who have made valuable contributions toward the perfection of the technique and its adaption to our special field.

### LOCAL VERSUS GENERAL ANESTHESIA.

Before taking up the aims of modern local anesthesia in detail, a few preliminary remarks on the relationship between local and general anesthesia may be in place. The dentist, whose practice concerns a very important but circumscribed portion of the body, is vitally interested in treating the organs intrusted to his care in such a manner that no damage to the entire organism will result from his interventions. The question of the relative toxicity of local anesthetics as compared with that of general anesthetics is therefore of greatest interest to him.

It was shown in our brief historical review that the earliest results in anesthesia were obtained in the domain of *general anesthesia*. The perfection of surgical methods of treatment was so closely connected with efforts to bring about the prevention of pain that these two movements have advanced hand in hand.

In order to perform a difficult and tedious operation with safety, the surgeon has always endeavored to paralyze the nervous centres to produce narcosis, thereby completely eliminating the sensation and will power of his patient. In the fields of minor surgery, ophthalmology, dentistry and others, in which surgical intervention renders such an aid desirable, investigators naturally endeavored to find methods by which the nerve terminals in a circumscribed area of innervation could be paralyzed, and the surgeon be enabled to operate while the patient was fully conscious. Thus began the evolution of local from general anesthesia. By local anesthesia we mean either those measures by which only the terminal ramifications of the nerves

in a definite area are influenced, as in *mucous* or *infiltration anesthesia*, or those by which a larger nerve trunk is intercepted directly, as in *conduction anesthesia*. In *infiltration anesthesia* the nerve terminals are for a certain length of time incapacitated from receiving stimuli, while in conduction anesthesia a particular nerve trunk is prevented from conducting impressions.

From the standpoint of the dentist, plexus or terminal anesthesia is therefore clearly differentiated from trunk or regional anesthesia; in the former sensation is blocked in the dental plexus, in the latter the nerve trunks supplying the plexus are intercepted.

The progress of local anesthesia has been accelerated above all by the want of perfect safety to the patient's life which still inheres in general anesthesia. Even if the more accurate method of so-called mixed anesthesia or sequences are correctly employed, 1 fatality in 7558 cases is still to be expected. At the Surgeons' Congress of 1910 Neuber estimated that 1 fatality still occurred in 2953 cases of chloroform anesthesia. These statistics are considerably aggravated by the very many errors that occur in general anesthesia, and by the frequently injudicious employment of this method in cases in which local anesthesia is clearly indicated. In minor interventions, such as tooth extractions, the employment of general anesthesia has often brought about the patient's subsequent death. General anesthesia, moreover, requires such preparations as are considered by most patients as decidedly disagreeable, and its induction is often followed by after-effects which are much more disturbing than those after local anesthesia.

Although the operative measures which are connected with the induction of local anesthesia may cause some fear and anxiety, the patient, being fully conscious of all the steps of the entire operation, enjoys the great advantage of not being exposed to any vital danger whatever, owing to the high state of perfection which local anesthesia has reached. The reported fatalities from local anesthesia have been due almost exclusively to the employment of cocaine; those cases attributed to novocain were undoubtedly due to a combination of causes, as will be shown later on. The methods of local anesthesia as prac-

tised in interventions in the head and the extremities, involve but little probability of vital danger to the patient, taking for granted that these methods are practised by skilled hands. In the extremely dangerous operations on the thyroid gland, which involve serious interference with the cardiac nerves, and which, when done under general anesthesia, are liable to produce syncope of the heart, it has now generally become surgical practice to employ local anesthesia. In dentistry its application is demanded all the more imperatively as the very nature of the field of operation in every respect indicates local intervention.

A knowledge of the sensibility and the nerve supply of the individual tissues is indispensable and, by a careful consideration of these conditions, a conscientious and experienced operator will always be able to operate painlessly provided the patient faithfully and patiently follows his directions. Here we touch upon a question of great importance in dental local anesthesia, *i. e.*, that of educating the patient to have faith in the operator. Some nervous persons regard the thought of being operated upon, under a local anesthetic while fully conscious as far more formidable than the struggle under a general anesthetic, and it requires calmness and discretion on the part of the operator to persuade them to submit to this method. It is the operator's duty, therefore, to justify fully the patient's reluctantly granted confidence by doing all within his power and skill to perform a perfectly painless operation. If he fails, the patient will lose forever the self-control which he has gained by the operator's mental suggestion, and will in the future swear by general anesthesia. In local anesthesia remarkable results can be obtained by mental suggestion, and in our hospital and private practice we have induced many a patient by such mental influence to submit to a local anesthetic.

In regard to technique, local anesthesia offers the great advantage of rendering the aid of an assistant unnecessary; on the other hand, the presence of a third person, an assistant, a woman attendant, or any responsible witness, is practically indispensable for social and medicolegal reasons. Several cases of sexual hallucinations following the injection of cocain solutions for extractions have been reported

in which the operator had difficulty in clearing himself owing to neglect of this necessary precaution.

"It has therefore been established as a general rule that neither the physician nor the dentist, without urgent reasons, should induce anesthesia when alone, but that an assistant, or at least another person, should be present. The presence of a witness is, indeed, imperative, owing to the additional fact that frequently during the application of anesthetics hallucinations or dreams occur which deceive the patient, and the operator may consequently become involved in a most disagreeable situation. Especially in treating patients under age great care is necessary, since any operative step which is undertaken without the guardian's permission may possibly be denounced as malpractice. A minor has no legal right to any serious decision, and for surgical operations, therefore, even for the most insignificant intervention in the human body, the consent of the parent, guardian, or legal representative is necessary. Dentists should take the greatest possible care in this respect when a serious oral operation or the induction of anesthesia is involved, and injections of a local anesthetic should never be made in minors without previous agreement. In such cases a plea of professional custom would hardly be accepted, the legal representative's special consent being always required." (Ritter.)

Local anesthesia offers an additional and important advantage over general anesthesia, inasmuch as local anesthetics can be very readily applied and require no lengthy preparation either on the operator's or on the patient's part. This is an extremely valuable feature, especially for ambulatory dental practice, in a big city as well as in the country, in the dentist's office as well as in the patient's home. The production of general anesthesia under difficult conditions or in unsuitable surroundings offers infinitely greater disadvantages, and its final success is incomparably more hazardous than that which can be obtained in dental operations under local anesthesia by a skilled hand almost at any time, in any place, and in almost any patient. To be sure, the dentist must have sufficient experience to cope with any difficulties that may arise in any case; he must have a thorough

knowledge of the anatomy of the face, be a master in painless manipulation, and be fully proficient in the technique of local injections; he must know exactly the pharmacological and physiological effects of his injecting solution, and, above all, he must be able to diagnose the general condition of each patient in order to treat him according to individual requirements; for there is no doubt that the behavior of the individual organism in absorbing an injected solution must largely determine the operator's method of procedure. The dentist can inject a smaller quantity of solution in greatly anemic or tubercular patients, and reduce the dose of the suprarenal extract, which is dangerous for the heart, without jeopardizing the success of his operation. Such patients will often tolerate only very superficial general anesthesia, and even then they are in constant danger, and pain is only partially abolished. The application of local anesthesia in such cases is far more advisable, since it guarantees perfect success and invariably meets with the patient's full approbation; for it must not be overlooked that with every successful operation we gain friends and advocates of local anesthesia among our patients, who will aid in popularizing a method which should be common practice with all dentists. To what extent general surgery has succeeded in replacing general by local anesthesia may be gathered from Braun's report.

Medicolegally, also, the application of local anesthesia gives the operator the advantage. To cite a medicolegal authority (Kupfer): 'After extensive observations I do not hesitate to maintain that general anesthesia, with the few exceptions enumerated, is unnecessary in operations in the oral cavity, and that, as a medicolegal expert, I should be unable to protect an operator from indictment in case of fatal accident from general anesthesia.' Schleich has pointed out that operations for which general anesthesia was employed, though they could have been performed with the aid of local anesthesia, were inexcusable from the humane standpoint as well as from that of the surgeon's legal responsibility. An important factor in placing the blame in fatal accidents under general anesthesia is the answer to the question whether the operation could not have been performed under

local anesthesia. In such a case the operator would have to prove the necessity of administering the general anesthetic chosen. General surgery is rapidly adopting local anesthesia for a great many major operations, and it behooves the dental profession, whose special field by its very nature calls for local intervention, not to lag behind, but unhesitatingly to keep abreast of the foremost modern, simple, safe and efficient methods available.

The large extent to which local anesthesia may be advantageously employed in oral surgery is attested to by the following excerpts from Braun's writings:

"One operation which we now perform exclusively under local anesthesia is that for empyema of the frontal and the ethmoidal sinuses. It is possible to make all operations on the frontal sinus, the chiselling away of the entire anterior and inferior walls, Killian's radical operation, Barth's operation, opening into the ethmoidal and sphenoidal sinuses. The field of operation is completely anesthetized and so anemic that the operation can be carried out much more easily, neatly and rapidly than under general anesthesia.

"We prefer local anesthesia in resection of the maxilla, since the admixture of suprarenin sufficiently guarantees the depth and duration of the anesthesia. By inducing scopolamin slumber we are enabled to do away also with the unfavorable psychic impression of the operation upon the patient.

"The blocking of the superior maxillary nerve in the sphenomaxillary fossa has been accomplished successfully and without any difficulty. The point of injection is found, upon palpation, to lie closely posterior to the inferior process of the malar bone, whence the needle is advanced inwardly and upwardly, its point reaching the maxillary tuberosity immediately back of the zygoma. Gently groping along the surface of the tuberosity, the needle easily advances, and, in a depth of from 5 to 6 cm. meets the superior maxillary nerve in the sphenomaxillary fossa. The patient immediately feels a slight pain radiating into the maxilla. The syringe is then attached to the needle, and from 5 to 10 c.c. of a 1 per cent. novocain solution are injected. The injection can be executed easily and safely. Anesthesia in the

*James W. Braumlee*

whole area of the superior maxillary nerve ensues almost immediately after the injection.

"The course of operation under local anesthesia is quite different from the usual. No interruptions of the operation as needed for the continuance of general anesthesia are required, and the operation can be completed in a minimum of time. Owing to the anemia from the suprarenin, the continual inundation of the field of operation with blood is avoided, and the few bleeding vessels can be quickly and conveniently compressed. The unobstructedness of the operative area permits of operating accurately and neatly. If blood flows into the pharynx, the patient is always able to prevent its aspiration, all reflexes being maintained. The patients' condition after the operation is most favorable; they leave the operating table perfectly well and rarely have to be put to bed. Owing to the effect of scopolamin, they frequently have little or no reminiscence of the operation. It is not saying too much that, owing to the employment of local anesthesia and suprarenin anemia, resection of the maxilla has lost all its terrors. Local anesthesia in this operation is not only equivalent to general anesthesia but far superior."

Major operations on the tongue also can be performed under local anesthesia. Braun undertook even more complicated operations, performing extensive extirpations of glands, temporary separation of the maxilla, and removal of maxillary bone fragments under local anesthesia. The anemia produced by the suprarenin greatly facilitates the technical execution of such operations. He also mentions 3 cases of carcinoma of the tongue and the floor of the oral cavity which were operated upon under local anesthesia.

"Local anesthesia has been charged with being too complicated, therefore unsuitable for extensive clinical practice. This, however, is unjust. Schleich's infiltration anesthesia, to be sure, was complicated, since the scalpel had to aid the syringe continually, and even then no satisfactory anesthesia could be obtained. The patients became restless, began to complain, and often general anesthesia had to be resorted to in the end. The operations were thereby unduly prolonged, and the patients as well as the operator were greatly disap-

pointed. Not so with the modern method of local anesthesia. All injections are made before the operation, if desirable even before sterilization of the field of operation. The injections require no longer, usually a much shorter time, than the production of general anesthesia. If several operations have to be made in succession, the assistant can make the injections in a separate room shortly before termination of the preceding operation, so that no time whatever is lost. If the correct technique is employed, there is no need for long waiting. After completion of the injection, we immediately prepare ourselves for the operation, and this preparation requires but a short time if sterile gloves and long-sleeved sterile operating-coats are worn. In the meantime the field of operation is sterilized. If the operation is begun within from eight to ten minutes following the injection, complete anesthesia will have been established. In large surgical institutions the saving in assistants and anesthetists afforded by the routine practice of local anesthesia is a considerable one.

"Since the patients retain consciousness, and a continual conversation can be carried on between operator and patient, disturbing movements of defense, if the anesthesia is temporarily superficial, can be prevented, and the patient is able to coöperate in making minor changes in position, etc., without the assistance of a third person." (Peuckert.)

"Local anesthesia in its present form is harmless. It was not perfect in the beginning, of course, and for the tyro in the technique it is even yet not entirely without risks. The introduction of novocain-suprarenin has greatly broadened the scope of local anesthesia, because large quantities of a most efficacious anesthetic solution can be introduced into the body with impunity. Among other operations, we employ local anesthesia for all strumectomies, all hernia operations except in children, the majority of operations in the male sexual organs, and in the rectum, also for resections of the maxillæ and operations on the tongue. In all these the use of cocain would be impossible. We inject 150 c.c. and over of a 0.5 per cent. novocain solution with an infinitesimal amount of suprarenin, as contained in the A tablets. I have never observed any intoxication or other untoward secondary

A handwritten signature in dark ink, appearing to read "H. A. Smith". The signature is written in a cursive, flowing style with large, sweeping loops.

effects from novocain, except occasional vomiting following very large doses (Braun).

These most favorable reports have been fully borne out by the experiences of oral surgeons in the World War, whose wonderful facio-maxillary restorations would simply have been unthinkable without the aid of local anesthesia by novocain-suprarenin.

**Selection of an Anesthetic.**—The practice of leaving it to the patient whether general or local anesthesia should be resorted to, is most reprehensible. Patients have no idea of the requirements of their case; all they wish is that the operation be painless. It is for the operator, and for him only, to decide just what is to be done, and how it is to be done. It goes without saying that, if the patient's mental condition demands it, general anesthesia must be resorted to, even though local anesthesia would be feasible. This applies especially to many children and those adults who act like children. Even then, the decision should be governed not by the patient's wishes but by the operator's judgment.

### **PRELIMINARY MEASURES IN LOCAL ANESTHESIA. THE OPERATOR'S DUTIES.**

While the correct administration of general anesthesia always requires elaborate preparations, the induction of local anesthesia necessitates only certain measures which will be discussed in the following paragraphs:

**Anamnesis.**—An accurate anamnesis usually can be best and most tactfully secured in leisurely conversation, by which the operator should inform himself about the patient's general physical condition. Special attention is to be devoted to persons affected with heart trouble, to those who are weakly and anemic, and convalescents from serious infectious diseases, such as influenza, also to physically depressed or nervously irritated individuals, and hystericals—all of whom require special care if they are to undergo any operation. In such patients the normal quantity of an anesthetic, as it is generally applied, is liable to produce more or less serious toxic effects, which,

as a rule, can be avoided by injecting a smaller quantity of the anesthetic and by reducing the percentage of the suprarenal extract. By calm self-possession in asking questions, and by kindly persuasion which will dissipate fear, the operator can instill in the patient sufficient composure and confidence to enable him to begin the operation. The patient's composure is of great importance in the first insertion of the needle, which is sometimes technically complicated, and can be accomplished only if the operator has his patient under perfect mental control. Success is assured as soon as the needle is introduced in the desired position. If the patient feels little or nothing of the needle puncture, he will quickly have full confidence in local anesthesia, and remain calm during the rest of the operation, provided the operator is skilful enough to carry his measures to a successful termination.

Even if inevitable pain should arise, the patient will be willing to bear it provided the operator has properly advised him of such a possibility. It may happen that deep alveolar or adjacent strata have not been reached by injection in the mucosa and have remained sensitive, as for instance, following fracture of a root. Or the operator may introduce a retractor or tweezers in an insufficiently anesthetized portion of the mucosa, thereby causing sudden pain. To avoid such unpleasant incidents, it is expected of the modern anesthetist that he foresee and consider all imaginable conditions that may arise, and reckon with all the factors that may defeat his object of painlessness. Every operator must be his own severe critic; he cannot afford to overrate his ability and experience, and he should know perfectly well how far he can trust his skill. He must be certain if he is technically able to produce such anesthesia as the conditions may demand, or whether he should take the precaution of notifying the patient in advance of the possibility of pain. This does not necessarily discourage the patient, rather does it contribute to inspiring confidence. Such a candid admission meets with the fuller appreciation the greater the operator's technical skill and manipulative ease, and it exemplifies modesty, which unfortunately has become a rare virtue. A certain class of practitioners are in the habit of guaranteeing their patients absolute painlessness, and exploit this fraudu-

lent promise in their advertisements; but such quackery cannot be condemned severely enough as being unprofessional and unscientific.

A calm reserve on the part of the operator is all the more in place, as, beside preventing pain, he is also obliged to perform the operation, and therefore faces a specially difficult task. Even though the operation be a minor one, he nevertheless has to exhibit great technical ability, alertness in observation, presence of mind, and determination.

Pulse and respiration must also be watched in order that disagreeable accidents which would interfere with the operation, such as dizziness, collapse, spasms, etc., may be duly anticipated and prevented. Experience shows that such accidents occur frequently in patients affected with heart trouble or some other constitutional disease; the operator should therefore proceed carefully and slowly. Every dentist ought to be able to make an examination of the heart and lungs by auscultation and percussion, and this requirement should be included in the dental curriculum.

It is out of the question, of course, that a thorough physical examination be made in every case; yet from the patient's history and pulse any trouble in circulation, blood-pressure or respiration can be recognized, and if the symptoms are in the least suspicious, complications can be avoided by a reduction of the quantity and strength of the injected solution. In dubious cases, of course, the patient's and the operator's interests are best safeguarded by calling into consultation an experienced diagnostician.

After having taken into account the patient's general health, the operator must next consider the local condition of the diseased area, which frequently determines the correct selection of the method to be employed for the prevention of pain. In cases of pericementitis or putrescence, anesthesia of the mucous membrane is to be avoided. The insertion of the needle would, in such cases, cause severe pain, and the injected solution, while passing through the focus of infection, is liable to absorb numerous toxins and bacteria which are bound finally to reach the blood and lymph vessels, involving great danger to the patient's life. In such cases nerve blocking by injection into remote healthy tissue is indicated.

From the foregoing it appears that the operator, who incidentally must be a capable anesthetist, assumes great responsibilities, since by faulty manipulation he may endanger the health, even the life, of his patient and may be held responsible for any damage caused by negligence on his part. As the danger for the patient increases proportionately with the intricate nature of the operative procedure, a perfect mastery of the anesthetic technique is imperatively demanded of the operator. Although the law does not require the presence of a skilled assistant in local anesthesia cases, the operator's responsibility is by no means lessened. Only when proved beyond doubt that he has fulfilled his duty in every respect will he be completely exonerated in case of accident, as for instance, the breaking of a needle in the tissues.

It is the operator's further duty to keep an accurate record of the patient, the disease observed, and the therapeutic measures employed. The method of injection applied and the quantity of solution injected must be noted, also any symptoms arising during the operation. Such a conscientiously kept record will prove invaluable in case of unlooked-for accident, as it will substantiate the fact that the operator was fully realizing his responsibility, and will influence a verdict in his favor.

**Eroticism.**—Sexual affections that may arise in connection with anesthesia are due to the strong general action of the anesthetic agent upon the central nervous system, which gives rise to a series of lascivious thoughts and conceptions similar to those produced by nitrous oxid anesthesia. In female patients such hallucinations very frequently affect the genital organs, and in neuropathic and hysterical persons, though they be fully conscious, persist as real sensations which are wrongly interpreted. That conditions simulating sleep may occur even in connection with local anesthesia the writer has personally noted in one case of novocain injection. In relation to this the case published by Körner should be cited: A woman had been locally anesthetized with ethyl chlorid for the purpose of extraction of a tooth, and though she had remained conscious claimed to have been assaulted during the operation. Owing to the presence of several persons who

had witnessed the operation from beginning to end, it was easy to explain this unpleasant incident.

"It is a fact, known to physician and dentist alike, that all anesthetics may produce erotic dreams. This is true not only of the agents employed in general anesthesia but, according to published records and my own experience, also of local anesthetics, especially cocain. One of the first to publish a comprehensive work on cocain anesthesia in operations in the oral cavity was the late Professor Dr. Witzel. He states that in one of his women patients, in whose gums he had injected eight drops of his cocain solution (0.08 cocain), sexual excitement was noted five minutes after the extraction. Shortly after the introduction of cocain in dentistry I applied this agent myself in subcutaneous injections, but abandoned its use after experiencing all kinds of disagreeable accidents, above all syncope and severe hemorrhages from extraction wounds due to failure of the blood-vessels to contract normally after the injection, also lascivious speeches and gestures, even confused narrations.

"It is only within recent years, since the adoption of the so-called cocain mixtures, that I have readopted such injections in my practice. But even in these cocain mixtures, which generally contain an admixture of adrenalin, these symptoms of sexual excitement appear in both male and female patients, especially the latter, and I should therefore advise every operator never, if possible, to administer local anesthetics to female patients in the absence of witnesses. In his monograph on *The Sequelæ and Secondary Effects of Local Anesthetics in Dental Operations*, Dr. Dorn, who is to be regarded as an authority on this subject, agrees with Lewin that the after-effect of cocain anesthesia does not depend upon the quantity of the drug injected, and that, as has been verified by the writer's own experience, even very minute doses suffice to produce secondary toxic effects. Dorn further reports that in women, after the application of cocain, erotic conditions may occur, sometimes even without any disturbance of consciousness, and I can verify these observations, which are very important for the case under consideration.

"Another case reported by Dorn is interesting: A girl, aged

twenty years, shortly after an operation under cocain, lapsed into a condition of tremendous excitement, respiration being considerably accelerated, pulse 102, and made voluptuous motions with her lips, without notably reacting upon being spoken to. After having remained in this condition of mental distraction and great excitement for about ten minutes, she gradually regained consciousness, and explained that she had dreamed of her fiancé.

"How closely cocain intoxication and hysteria may be related, and how dangerous this combination may be for the operator, is proved by the following case published by Hentze: A young woman had a tooth extracted in the clinic under local anesthesia. She showed symptoms of cocain intoxication and hysterical fits, but soon recovered and returned home. Soon afterward the assistant, who had been present at the operation and whom she had not known even by name, received love letters from the woman, which remained unanswered. Three days following the operation the patient committed suicide by shooting, after having written to the assistant that she intended to take her life unless she received a reply. It was ascertained afterward that the woman was engaged to some other man." (Ritter.)

These reports of specially dramatic cases serve to emphasize that the presence of a third person, who may be called upon to testify, constitutes a most valuable safeguard medicolegally, if patients should experience sexual affections and accuse the operator of immoral attempts. While such cases are of fairly frequent occurrence in connection with general anesthesia, and local anesthesia with cocain, fortunately only very few such incidents have been observed following novocain-suprarenin injections, which is another strong argument in favor of this method.

## AGENTS FOR LOCAL ANESTHESIA.

After these general considerations, the question arises by what means a satisfactory, safe, and effective local anesthesia may be obtained. There are a great number of anesthetics which have been

applied in various ways more or less successfully, but few of these deserve serious consideration in view of the severe specifications demanded of an up-to-date anesthetic. Like the narcotics, almost all anesthetics are poisonous to the vital human organism, and their toxic effects upon the general system must therefore be checked by suitable dosage and solution.

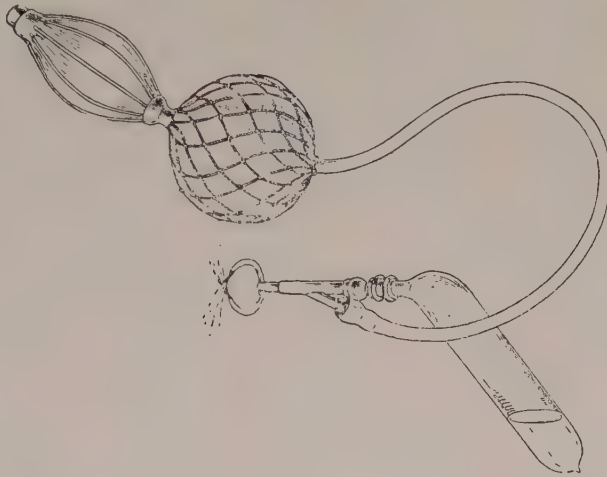
**Anesthesia by Freezing.**—The physical methods of anesthesia by freezing and pressure, which were the earliest practiced, are primarily localized in their effects. Anesthesia by freezing is based on the principle of depriving the tissues of as much heat as possible by the application of congealing agents, such as the well-known ether spray, which produces a condition of analgesia in the tissues. Owing to the great loss of heat, the tissues of the living organism are changed into a solid state. The aqueous tissue fluids, blood and lymph, solidify like water during frost, affecting the sensory nerve endings in such a way as to render them incapable of transmitting impressions to the central organ. The sense of touch is thereby affected but little or not at all, so that anesthesia by this means consists not so much in a deadening of the entire complex of senses as in the abolition of the sense of pain, *i. e.*, analgesia.

The epidermis, and to even a greater extent the mucosa, are permeable to gaseous bodies. The gas which is developed upon application of ethyl chlorid to the warm surface of the mucous membrane penetrates the epithelial retiform interstices, the tissue pores and glands, owing to the high pressure caused by the deprivation of the tissues of heat. Anesthesia of the affected nerve elements is thus rapidly produced, but it usually wears off just as rapidly.

Anesthesia by ethyl chlorid refrigeration has lost much of its importance in dental practice. In most cases it is painful and is of value only in lancing abscesses and in extracting anterior teeth or roots which are decayed and loose in their sockets. Besides, the anesthesia is difficult to produce within the mouth and very transitory, hence suitable for short operations only. Kühner recommends a freezing apparatus which is easily attached to ethyl chlorid tubes (Fig. 1). With the aid of a permanent air current, the ethyl

chlorid, emanating from two fork-like openings, is quickly sprayed and evaporated on both sides of the alveolar process.

FIG. 1



Bifurcated ethyl chlorid spray for simultaneous freezing of the labial and buccal mucosa.  
(After Kühner.)

**Anesthesia by Pressure.**—Besides freezing, compression of nerve trunks has long been employed for the production of a limited analgesia. By firmly constricting a portion of the body, as, for instance, the arm, the sensation of pain can be notably diminished, yet not completely abolished. In dentistry the simple method of anesthesia by pressure is still applied in obtunding hypersensitive dentin or exposed pulps, but profound anesthesia is only possible by means of injection.

Schleich adopted the principle of physical pressure for the production of anesthesia by completely filling the tissues with an injected fluid, thereby producing infiltration, or artificial edema. The pressure and tension obtained in this way incapacitate the affected nerve filaments to convey stimuli. By employing very weak cocain solutions (0.1–0.2 per cent.), Schleich obtained both a physical and a chemical action upon the tissues. To a limited degree, anesthesia of the mucosa in the alveolar region is based also upon such a combi-

nation of the pressure and the chemical action of the injected solution; the latter factor is, however, of decisive importance.

Owing to the peculiarity of the maxillary and mandibular tissues, where firm layers of mucous membrane are stretched over bone of varying porosity, it is necessary to inject a strong solution with a certain amount of pressure through the periosteum so as to reach the interior of the bony alveolus. This alone insures the infiltration of the deeper seated nerve branches. On the other hand, conduction anesthesia can be employed without any marked amount of pressure.

**Chemical Anesthetics.**—All the anesthetics in more or less general use today represent organic chemical combinations which are applied upon or within the tissues in the form of suitable, generally aqueous, solutions. For the anesthetization of mucous surfaces cocain solutions of high percentages or concentrated novocain solutions are employed, while for injection into the connective tissue dilute solutions are always indicated. The external application of these drugs upon the oral mucosa produces a superficial anesthetic effect, because the lymphatic fluid, which is distributed through the tissue, readily seizes the foreign salts introduced, dissolves them and carries them to deeper strata. It must be admitted that cocain is more effective than novocain for anesthesia by surface application, as the latter drug is apparently slow in penetrating the mucous membrane.

**Solubility in Water.**—As the tissue fluids are of an aqueous nature, only aqueous solutions of anesthetics are effective, and the anesthetizing power of these drugs is directly proportionate to their solubility in water. For this reason alkaloids which are very readily soluble in water, such as cocain, eucain, tropacocain, novocain, and others, yield the best results, especially when these have been made into salts such as hydrochlorids, with appropriate acids, in order to increase their solubility in water.

**Toxicity.**—The toxicity of these anesthetic salts is reduced to a minimum by various measures. The concentration of the solution is restricted to certain limits, and the solution itself reacts in the human system according to certain fixed laws. If the patient is given a solution of appreciable strength by the mouth, a much too rapid

and extensive absorption takes place, which is generally followed by severe toxic symptoms. The same quantity, on the other hand, is very well tolerated subcutaneously, and is generally absorbed without any local disturbances. Nevertheless, even in subcutaneous application, the maximal dose, which varies with different salts, must not be exceeded; for most anesthetics, besides their action upon the nerve endings, produce toxic conditions in the central nervous system by way of the circulation. While partly paralyzing the brain and its special centres, they exert an irritating and destructive influence which is the greater the larger quantities are introduced into the blood. Besides, secondary effects may occur which are specific for each drug, so that the conscientious operator has every reason to familiarize himself to the smallest detail with the effects of the anesthetic which he employs.

There are many substances which in solution act upon living tissue. While some solutions have almost exclusively physical effects, others, on account of their chemical composition, cause more or less marked changes which appear as local intoxications. These manifest themselves as disturbances or arrest of function, stimulation, or paralysis of sensory nerves, damage to tissues, and sloughing. In the large majority of cases such intoxications cause permanent changes at the place of injection, such as edema, inflammation and necrosis. The desired local action of such solutions can only be brought about by binding them to the desired locality, *i. e.*, preventing their immediate absorption into the circulation.

In all probability the solutions which are thus retained within the tissues decompose rapidly, thereby losing their original toxicity. The resulting constituents reach the circulation and are absorbed more or less rapidly. The effectiveness of the solution, therefore, depends upon the retardation of its absorption; at the same time tissue damage is avoided, provided the injected agent possesses other favorable properties. Novocain and suprarenin are agents which, without noteworthy irritation and without tissue damage produce a local intoxication manifested by temporary sensory paralysis.

**Cocain and its Substitutes.**—Of the innumerable local anesthetics offered in the market, the following should be mentioned: Cocain and its substitutes, *i. e.*, novocain, eucain alpha and beta, acoin, tropacocain, holocain, nirvanin, anesthesin, orthoform, stovain, alypin, yohimbin, and aneson, all of which with a few exceptions have been discarded after having been in vogue but a short time. Cocain, being the original preparation, has tenaciously held its ground despite the alarming sequelæ which have frequently been observed following its injection. It possesses, however, so many serious disadvantages, above all a specifically high toxicity, that its employment is being limited more and more, greatly to the benefit of suffering humanity.

**Toxicity of Cocain.**—"Transitory disturbances in brain function, chiefly conditions of excitement, occur in certain patients either very soon or as late as two hours after the introduction of cocain. Some patients chatter with trembling voice, or exhibit symptoms resembling intoxication. Others talk confusedly, and show other symptoms of mental derangement and incoherence. They also experience hallucinations affecting the senses. The excitement sometimes is aggravated to the highest degree. Fits of fury and delirium lasting for days, combined with hallucinations, mania of persecution, etc., have frequently been observed. The delirious attacks may also occur intermittently. In one instance, a woman jumped up from the operating chair in a delirious fit, drank water, and, upon reaching home and retiring, had another spasm, though afterward she could not recollect the incident. During the stage of excitement in another woman, strongly erotic symptoms were observed. The excitement sometimes alternates with depression, which assumes the form of pronounced melancholia associated with delirium of persecution, or of profound apathy such as is generally observed after excessive excitement." (Lewin.)

"Cocain intoxication is either acute or chronic. As a rule, the first symptoms of an acute intoxication appear within ten or fifteen minutes after the injection, sometimes, however, not until half an hour or three-quarters of an hour afterward. These symptoms are the following: Precordial depression, closely resembling the pain in

pulmonary and cardiac oppression, very thin and rapid pulse, pallor of the face, coldness of the extremities, abundant perspiration, high temperature which may rise to 40° C., irregular respiration, disturbance of the digestive tract in the form of bilious vomiting sometimes associated with diarrhea, diminished urination and anuria, which in some cases was observed from twenty-four to forty-eight hours after injection. The psychic disturbances are of a most pronounced character, and manifest themselves in the form of excitement or garrulousness; sometimes the patient sheds tears, or exhibits great anger or fury. The tactile sense is impaired especially in the hands, a prickling sensation sometimes being noticed. Cases of cramps, or symptomatic cocain epilepsy, have been observed, followed by a condition of motor and sensory paralysis lasting several days. Hysterical attacks have also been noted. Cases of death from cocain intoxication have occurred suddenly, in some cases two minutes after the employment of this alkaloid, in others within from half an hour to five hours. While the untoward after-effects are not often fatal, nevertheless the disagreeable secondary symptoms last several hours, sometimes several days. Post-mortem examinations have revealed acute congestion of the lungs. Sometimes numerous small infarcts, also edema of the lungs, inflammation of the cardiac muscle and the dura mater, have been observed, although the last symptom is not quite certain." (Brouardel.)

"The mildest form of intoxication consists in a sudden sensation of dizziness soon after injection, disappearing just as rapidly as it came. Faintness may ensue with rapid and thin pulse, tingling and cold in the limbs, irregular and difficult breathing, and cold perspiration. In severe cases there is loss of consciousness, followed by a feeling of weakness of several hours' duration, also vomiting. Dangerous cocain poisoning is usually heralded by epileptiform convulsions with exophthalmus and unconsciousness. Sensibility, motility and all reflexes, the corneal reflex last, are lost; the patient is in a deep coma and death ensues through paralysis of the respiratory centre.

"Patients naturally inclined to cramps are more liable to have cocain convulsions than others. In nervous individuals cocain intoxication may manifest itself in the form of illness lasting from three to

four weeks and accompanied by intermittent cramps. This by no means completes the picture of the manifold symptoms of acute cocain intoxication, as there is hardly any sign of disease which may not be met with in these cases.

"Cocain intoxication of the central nervous system occurs when the blood, circulating through it, contains even for a moment, the alkaloid in a concentration affecting that system." (Braun.)

By a long series of carefully conducted experiments E. W. Sike-meier<sup>1</sup> has proved, contrary to recent teachings, that adrenalin injected simultaneously with or after cocain does not reduce the toxic effect of the alkaloid. Equal doses of cocain with or without adrenalin had the same effect, the lethal dose also being the same. The anesthetic effect of cocain is by no means intensified by the addition of adrenalin, and the same quantity of cocain is required no matter whether adrenalin is added or not.

The limit of concentration of a non-toxic cocain solution cannot be accurately determined. Cases have been observed in which more than 2 grams of cocain were tolerated without serious sequelæ, while very low doses of 1 cgm. have proved fatal. In regard to toxicity, it is essential to note whether strong or weak doses of solution are employed, also whether the drug is applied to the mucosa or subcutaneously. But even in subcutaneous injection the alkaloid may accidentally enter a vessel directly and reach the circulation, so that a large quantity of the poison is conveyed to the brain in a relatively short time. The absorption of the solution takes place much more rapidly in highly vascular tissue, such as the oral mucosa, the periosteum, etc. Cases of cocain intoxication after minimal doses must be attributed to idiosyncrasies.

Cocain is a pronounced protoplasmic poison. It immediately retards the ameboid movements of certain cells, and inhibits diapedesis of the leukocytes. Cocain furthermore acts as a specific toxin upon the nerves, kidneys, and heart; diseases of these organs, therefore, constitute a contra-indication to this drug. It is also contra-indicated

<sup>1</sup> Archiv f. klinische Chirurgie, 1906, vol. lxxviii.

in anemia, chlorosis, neurasthenia, nephritis, heart disease, physical debility of old age and convalescence.

**Proprietary Preparations.**—Dental journals still publish advertisements of proprietary preparations or mixtures. Concerning these concoctions it should be stated that the simpler the composition of a solution, the easier it is to determine its isotonic toxicity and chemical action. The various, apparently favorable admixtures in most cases cause disturbances arresting the healing process or resorption. These facts should be generally realized by dentists. Proprietary preparations are barred from surgical clinics and dentistry too should emancipate itself from the use of glaringly advertised proprietaries.

After an experience with injection anesthesia extending over nearly twenty years, we feel justified in making a statement which characterizes the present status of the question of solutions. Cocain, even in infinitesimal doses, may have toxic secondary effects. Like Lewin we must assume that "the after-effect of cocain anesthesia does not depend upon the strength of the dose applied," but the patient's physical and mental condition plays an important role.

That novocain, on the other hand, is a complete substitute for cocain has initially been affirmed by Braun. We can but fully endorse his excellent discussion of this subject, after having employed novocain to the fullest extent in dental practice, and do not hesitate to emphasize that cocain preparations must be banished from injection anesthesia, and novocain adopted as the most suitable anesthetic so far discovered.

**Quinin and Urea Hydrochlorid Compounds Contraindicated.**—Certain quinin compounds, Riethmüller<sup>1</sup> writes, have within recent years been employed for the production of local anesthesia in minor surgery, and the combination of quinin and urea hydrochlorid has received quite some discussion among the dental profession to whom this combination has been offered under proprietary names. A great many untoward sequelæ, however, have been produced by its use hypodermically, such as local hemorrhage, oozing, extensive

<sup>1</sup> Dental Cosmos, February, 1913.

sloughing, abscess, continued fever, swelling, gangrene, and tetanus.<sup>1</sup> Boiling of quinin for the purpose of sterilization not only produces deterioration of the drug chemically, but materially impairs its therapeutic efficiency. H. Prinz<sup>2</sup> scrutinizes the value of this anesthetic compound, and reaches the following damaging conclusions: While it is true that quinin and urea hydrochlorid is not poisonous in the doses in which it is injected for local anesthesia purposes, yet, since it reacts strongly acid, it severely damages the tissues in the injected area, edema and induration being the usual sequelæ. The injection is more or less painful, and the mixture interferes with the progress of wound-healing. The excessive length of duration of the anesthesia, and the paralysis persisting from several hours to several days, is most disagreeable and often alarming to the patient. If applied in concentrated solution to the mucous surfaces, this compound is only sparingly absorbed, and very little anesthesia is produced. Besides, its most persistent bitter taste renders its use undesirable for this purpose. "From the foregoing we conclude that quinin and urea hydrochlorid, when employed as a local anesthetic in dental operations, possesses no advantages as compared to novocain. While, *a priori*, its non-poisonous nature indicates safety, this safety is only relative, as it refers to larger doses. The small dose of novocain necessary for the average dental operation may be considered a safe dose."

### NOVOCAIN AND ITS SOLUTIONS.

The following principles have been laid down by Braun for the selection of a local anesthetic:

1. The substance must be less toxic than cocain in proportion to its local anesthetic power. Less toxicity alone, however, is not sufficient for its offset by the necessity of injecting larger quantities.
2. The agent must not cause the slightest irritation or tissue injury, but must be absorbed from the place of application without any secondary offset, such as severe hyperemia, inflammation, pain-

<sup>1</sup> Dental Cosmos, February, 1911, p. 253; October, 1913, p. 1061; November, 1913, p. 1196.

<sup>2</sup> Ibid., January, 1911.

ful infiltrates or necrosis. Only when these conditions are fulfilled can we assume that the healing of wounds will not be interfered with. The use of strongly acid or alkaline substances is not permissible, inasmuch as they cause local tissue injury. On account of this important requirement many of the newer anesthetics have failed in their purposes.

3. The agent must be soluble in water and its solutions reasonably stable and sterilizable by simple means.

4. It must be possible to combine the agent with suprarenin.

5. For application upon mucous membranes, the anesthetic must be able to penetrate rapidly.

**Novocain.**—Novocain fulfils these requirements. It was discovered by Einhorn in 1905. It is a white powder, readily soluble in water in equal proportions. The salt crystallizes in alcohol in the form of small needles which melt at  $156^{\circ}$  C. It dissolves in the proportion of 1 to 1 in water, forming a neutrally reacting liquid. In cold alcohol it is soluble at the ratio of 1 to 30. Aqueous solutions of novocain can be heated up to  $120^{\circ}$  C. without undergoing decomposition. After suprarenal extract has been added to a novocain solution the mixture should be boiled for a short time only, as the active principle of suprarenin loses its effect by continued boiling, and the drug itself is decomposed.

Novocain has the same action on the peripheral sensory nerves as cocain. A 1.5 or 2 per cent. solution is fully sufficient to anesthetize within ten minutes even large nerve trunks.

"The 1 per cent. novocain-suprarenin solution serves almost all purposes and is most suitable for general surgical practice. . . . Without fear of toxic secondary effects, 1.25 gram novocain, *i. e.*, 250 c.c. of a 0.5 per cent. solution, or 125 c.c. of a 1 per cent. solution, and more, can be injected. If a 2 or a 4 per cent. solution is employed, a dose of 0.8 gram novocain, *i. e.*, 40 or 20 c.c. of these solutions respectively, should not be exceeded; for injections into tense and highly vascular tissue, such as the gingivæ, a lower dose will suffice. On the whole, little attention need be given to the dosage of novocain, unless an attempt is being made to operate under local

anesthesia in an all but hopeless case that presents an enormous operative field. To this feature of novocain the remarkable progress of local anesthesia is due in a large measure." (Braun.)

Of the 2 per cent. novocain-suprarenin solution, Seidel injected 30 and 40 c.c. in one and the same patient in succession, and 50 c.c. each in some forty cases without observing any toxic symptoms. A certain quantity of the 2 per cent. solution is tolerated far better in regard to wound healing and absorption than a three or four times larger amount of correspondingly weaker solution. In other words, the infiltration of tissue with large quantities of solution is less favorable than the use of smaller and more concentrated amounts which possess a large radius of action.

**Systemic Effects after Absorption.**—The systemic effects after the absorption of novocain are hardly noticeable, neither circulation nor respiration being influenced. The heart action is not affected. From 0.15 to 0.2 gram, when injected subcutaneously in rabbits, produces hardly any change in the tracings of blood-pressure and respiration as registered by the kymograph. Novocain does not produce mydriasis, disturbances in accommodation, or increase in intra-ocular pressure. Its low toxicity can easily be demonstrated by comparing the lethal dose of novocain with that of cocain or stovain per each kilogram of body weight in different animals.

The comparative lethal doses of these drugs, when injected subcutaneously, are per kilogram body weight: In rabbits, novocain, from 0.35 to 0.4 gram; cocain, from 0.05 to 0.1 gram; in dogs, novocain, 0.25 gram (not yet lethal); cocain, from 0.05 to 0.07 gram. The minimal lethal dose in rabbits per kilogram body weight is 0.73 gram of novocain when injected subcutaneously in a 10 per cent. solution.

**Effects of Novocain.**—Novocain solutions are absolutely non-irritant. Even if 20 per cent. solutions or the pure powder are introduced into fresh wounds, not only no untoward symptoms whatever are observed, but the local inflammation is reduced, as we have been able to demonstrate. Solutions can be boiled any number of times without disintegration. The toxic effect of novocain is relatively

light. In very high doses tonicoclonic spasms, together with opisthotonos, great agitation, accelerated and shallow respiration, are noted. The maximal dose for subcutaneous injection is 0.8 gram. Novocain is seven times less toxic than cocain, and three times less toxic than its other substitutes.

Novocain has a transitory vasodilator effect, but when combined with a suprarenin, is fully equal to cocain in its anesthetic power. The unfavorable vasodilator action of novocain is counteracted by combination with suprarenal extract; in fact, its anesthetizing power is considerably enhanced by this admixture.

Another great advantage of novocain lies in the fact that it is not a habit-forming drug. This is of vital importance, when we remember that many an unfortunate victim of the cocain habit has been started in this fatal practice by the application of cocain by well-meaning dentists or rhinologists. Since the Harrison Act placed the ban upon the sale of cocain and cocain mixtures except upon a licensee's prescription, the exemption of novocain from this law is a matter of momentous interest to the dentist.

Novocain is "an ideal anesthetic which cannot only be substituted for cocain in every case, but considerably enhances the safety of local anesthesia owing to the possibility of safely injecting much greater quantities of a strongly active anesthetizing solution." (Braun.)

"We must emphasize that our experiences fully coincide with those of Braun, Hainecke and Læwen. The results of 255 observations have proved that novocain is a non-irritant, rapid and intensely effective local anesthetic, which produces no toxic secondary effects, no irritation or necrotic symptoms. Novocain does not impair the action of suprarenin in the least, and can be fully sterilized. We have arrived at the conviction that novocain at present is the only known agent fit to take the place of cocain in surgery, and we can warmly recommend it for use in medical practice." (Danielsen.)

"A résumé of our clinical experiences shows that novocain represents a non-toxic and superior substitute for cocain for the purpose of local anesthesia; its maximal dose is 0.5 gram, it allows of an ideal

combination with suprarenin, and produces absolutely no irritation." (Liebl.)

**Novocain-suprarenin (NS).**—"The effect of suprarenin, far from being impaired by novocain, seems to be enhanced by this drug, as my very first tests have shown and numerous subsequent investigations have corroborated. The anemia which follows novocain-suprarenin injection is much more pronounced than when a pure suprarenin solution or a cocain solution containing an equal amount of suprarenin is employed. Independently of my observations, Dr. Biberfeld had noted the same curious fact. The combination of novocain and suprarenin, and the behavior of these two drugs toward one another, is of great advantage in local anesthesia, inasmuch as only very small quantities of suprarenin are needed to intensify the local anesthetic action of novocain to as high a degree as is peculiar to cocain-suprarenin solutions. These small admixtures of suprarenin also retard absorption and thereby render the anesthetic action purely local and limited to the place of injection. The power of these novocain solutions in regard to intensity, duration, and extension of anesthesia is at least as great as that of cocain solutions. All the operations described in my book can equally well be performed with novocain as with cocain solutions. For infiltration and conductive anesthesia, novocain in combination with suprarenin is the most suitable agent." (Braun.)

**Suprarenin.**—Suprarenin is the active principle of the suprarenal gland and possessing the specific property of contracting the walls of the capillaries and small bloodvessels within an injected area. The toxic effect of the injected anesthetic solution is thus minimized and its absorption retarded while, at the same time, anemia is produced so that the field of operation remains unobstructed by parenchymatous hemorrhage. In former years, suprarenal preparations were secured from the suprarenal glands of sheep and oxen. Synthetically prepared suprarenin, however, is obtained chemically pure and is less toxic, and more stable than the organic product.

Suprarenin is a grayish-white powder, slightly soluble in water, and readily soluble in dilute acids. It is the most powerful of all

chemical substances thus far known, being very active even in a dilution of 1 in 100,000. The toxic symptoms produced by suprarenin consist chiefly in palpitation of the heart, oppression and difficult respiration.

Suprarenin has no anesthetizing power, but, as has been said, produces contraction of the small bloodvessels and capillaries. A solution of 1 to 1000 seems to be most favorably indicated for injection.

Contraction of the bloodvessels occurs also when suprarenal extract is applied locally to the mucous membranes, or injected into the tissues.

Suprarenin, according to the findings of Kochmann and Esch<sup>1</sup> has the property of preparing the nerve tissue for the reception of the local anesthetic, in about the same manner as a mordant is applied in the dying industry for rendering the cloth more receptive of the dyestuff.

Adrenalin is an organic product mixed with a small quantity of chloretone for the purpose of rendering the solution more stable. This effect of chloretone, however, has been disputed by B. Müller, who found that chloretone impairs the action of adrenalin.

Synthetic suprarenin in solution is stable only to a limited degree after the bottle has once been opened. In private practice it is best to make a fresh solution from tablets, as cases present themselves. "The very convenient tablets," as Braun writes, "are preferable to any other form of dispensing alkaloids used for medical purposes. This is especially true of unstable drugs like suprarenin which, in dry tablet form, keeps for a long time."

For injection, a slightly acidulated sodium chlorid solution is used as a base to which suprarenin is added in the concentration of 1 in 1000. Even fractions of 1 mg. of suprarenin suffice to produce anemia in a very large operative field, if the anesthetic mixture has been introduced in sufficient quantity and evenly distributed in the tissue, *i. e.*, along the periphery of the area to be operated upon.

If synthetic suprarenin is exposed to light for some time, the originally clear solution undergoes a reddish, later a brownish, discoloration. The chemical changes which produce the discoloration

<sup>1</sup> Deutsch. Zahnärztliche Wochenschrift, vol. ii, p. 65.

considerably enhance the toxicity of suprarenin; hence discolored solutions should be invariably discarded. The syringe too, should always be emptied after use lest some decomposition products remain in the barrel.

Biberfeld has ascertained that synthetic suprarenin is also clinically equal to the organic product. In my opinion, however, the organic product generally exhibits greater toxicity than the synthetic preparation.

**Action of Suprarenin.**—Suprarenin solution when applied externally upon the mucous tissue, produces anemia within from one-half to five minutes; if injected hypodermically, in from fifteen to thirty seconds. The anemia is complete as soon as the originally pink mucous tissue has assumed a pale, whitish shade. The action of the solution extends only within a radius of from 1 to 2 cm. After the anemia has disappeared, primary dilatation of the bloodvessels ensues, until gradually the vascular walls return to their normal condition.

**Toxicity of Suprarenin.**—Suprarenin may exhibit an intensely toxic action if introduced into the circulation in excessive quantity or concentration. The toxicity is greatest when the drug is injected intravenously, viz., directly into the blood. According to Batelli, its toxicity is forty times greater when it is injected intravenously than when it is introduced subcutaneously. Even the doses employed for dental purposes sometimes produce untoward toxic symptoms, such as palpitation of the heart, acceleration of pulse, dizziness, nausea, headache, fainting and collapse, especially if stale solutions are employed. The local symptoms of intoxication from decomposed solutions consist in after-pain and swelling. This danger is reduced to a minimum if a fresh solution is prepared from tablets, while solutions made with liquid suprarenin are always risky.

In very rare cases, a patient may complain of sudden sharp pain in the lower spine and kidney region which rapidly disappears. This is undoubtedly due to the action of the suprarenin upon the patient's suprarenal glands and may indicate the existence of disturbed suprarenal function.

Braun injected increasing doses of 1 to 1000 suprarenin solution

subcutaneously into his forearm and observed systemic symptoms at a little over 0.5 mg. Five minutes after injection he noted oppression in the chest, palpitation of the heart, rapid and shallow respiration, increase of pulse-rate of from 64 to 94 per minute. He was compelled to lie down, but after one minute and a half these symptoms disappeared. No glycosuria ensued. Of an adrenalin solution diluted ten times with normal salt solution, Braun tolerated up to 1 mg. without secondary disturbances.

Some practitioners claim that for the correct preparation of novocain-suprarenin solutions, fresh suprarenin (1 to 1000 solution) should be added drop by drop to a 2 per cent. novocain stock solution.

The size of the drops is measured by a standard pipette. Seidel justly emphasizes accuracy in the size of the drops, after having shown that 3 c.c. of synthetic suprarenin furnished 36 drops with a dropper, 93 with a pipette, and 45 with the original bottle. Organic suprarenin differed in this respect from the synthetic product, the same quantity yielding 34, 73, and 25 drops respectively. It is important to avoid the sudden introduction of a large quantity of the drug into the blood. Even a 1 to 1000 solution is extremely efficacious; hence, suprarenin should be injected only in the dilute form as an admixture to an anesthetizing solution.

A fortunately rare danger consists in postoperative hemorrhage, which has been observed in reaction to the abnormal vascular contraction followed by hyperemia, especially after tooth extractions. Suprarenin by its extremely local action most effectively retards local circulation, and, in some cases, may endanger the dental pulp. This danger, however, does not seem to exist with the now generally adopted dosage of our injecting solutions, as Euler and Scheff have proved by experiment. The latter found that novocain-suprarenin solutions do not in the least disturb either the vitality of the teeth anesthetized or that of the approximating teeth, "provided the perfect vitality of the pulp before application of the drug has been established beyond all doubt." (Scheff.)

Synthetic suprarenin is marketed in the form of 1 in 1000 solutions ready for use, to which a slight trace of hydrochloric acid has been

added for the sake of stability, or in the shape of compressed tablets of 1 mg. each. The combined novocain-suprarenin tablets E, T and H, however, are far more practical. While in solution suprarenin keeps for a short time only, it remains unchanged for a long period in the dry tablet form. Since the sterility of these tablets is not always uniform and certain, solutions made from tablets must be sterilized before use.

The dosage of suprarenin is, according to Braun, of little importance in local anesthesia, because the dilutions of 1 in 100,000 and of 1 in 200,000 will not produce any systemic effects. Hospital internes are employing considerable doses in collapse due to infectious diseases, *i. e.*, as much as 6 mg. per day, even 24 mg. per day. (Kirchheim.) The doses required in local anesthesia may therefore be considered innocuous as long as a pure and fresh preparation, preferably one made from tablets, is employed.

The concentration of the suprarenin in the anesthetic solution, however, is of importance, as it determines the intensity of the local effect of the anesthetic and the duration of anemia. This anemia should never be so pronounced as to interrupt the circulation of the blood completely. Excessively strong suprarenin may cause gangrene, especially in arteriosclerotics. Generally, however, the doses indicated above produce no untoward action whatever in the tissues.

In patients with heart disease, in children, and in the aged, it is advisable to reduce the concentration of the suprarenin by adding to one tablet E a little more of the Ringer solution (see page 67), 1 c.c. of which gives a 2 per cent. novocain-suprarenin solution when one tablet E is dissolved in it. The excess of Ringer solution also reduces the novocain contents, and a less toxic solution is obtained, but the anesthetizing power of the solution is still more than sufficient, as innumerable practical cases have shown.

### THE INJECTING SOLUTION OF NOVOCAIN-SUPRARENIN (NS).

**The Injecting Solution.**—Novocain-suprarenin (NS) solutions which are intended for injection must always be of the purest quality;

they must be crystal-clear and not contain any admixtures; nor must they have come in contact with any impurities during the process of preparation. The smallest traces of turbidity or discoloration to pink, rose or yellow indicate incipient chemical decomposition which considerably increases the toxicity of the solution. A freshly prepared solution should, therefore, be used up as quickly as possible and any remnant be protected from light by covering it with ruby glass. Solutions of body temperature act better and more rapidly than cold solutions.

The quality of an injecting solution is generally evinced by its behavior toward the living organism. It should penetrate the tissue cells without producing any lesions in the way of distention or contraction. This property of a solution is called isotonia.

**Isotonia.**—Every body cell is protected from the tissue fluids by a semipermeable membrane which regulates the interchange of the fluids between the cell contents and the cell environment, *i. e.*, maintains metabolism. If the fluids within and without the cell are of the same consistency, if their percentage in salts is the same, then isotonia or equal tension is present. If, however, the percentage in salts in the environment of the cell exceeds that within the cell, then there is a tendency to equalization. Since, however, only water, not salts, diffuses through the plasmatic membrane, the salts, on the other hand, have a tendency to absorb the water from the cells, the water leaves the cells, causing a contraction; or, if the reverse is the case, *i. e.*, the cell environment is deficient in salts, a distention of the cell ensues. The power that regulates this interchange is called osmotic pressure. Cell disturbances are caused by difference in concentration, *i. e.*, difference of osmotic pressure on either side of the cell membrane. If, then, a solution is injected which does not conform with the amount of salts in the tissue, the cells are either contracted or distended. The absorption of the injected solution is retarded and a pathological condition ensues which often assumes the form of edema. *Hypertonic solutions*, *i. e.*, those rich in salts, and *hypotonic solutions*, *i. e.*, those poor in salts, may, in unfavorable cases, produce necrosis of the tissues, especially when they contain highly toxic and deleterious drugs such as cocain, phenol and acids.

Numerous solutions in the market not only contain admixtures of highly toxic drugs but also lack sufficient neutrality; in other words, they are not isotonic but heterotonic, if we may use this term.

Novocain, on the other hand, penetrates the tissue cells, the red-blood corpuscles, etc., without producing any irritation; it in nowise impairs the hemoglobin, and permeates even the nerve substance, so that its anesthetic effect is fully developed.

The injected fluid rapidly enters the circulation, even in subcutaneous injections. One circulation is completed in the human body within twenty-seven seconds, but the injected fluid reaches the heart and the central nervous system in a much shorter time. This explains the extraordinarily rapid action of toxic agents when injected into the organism. The toxic action of the solutions, especially of the suprarenin, is often very marked and rapid, so that almost immediately after the introduction of the first few drops of solution the pulse undergoes considerable acceleration, culminating in oppression. In such cases greatest caution, above all very slow injection, is required.

Harmless solutions, such as the NS solution advocated, are very readily excreted by the urine and the perspiration, so that untoward effects of a general nature need not be anticipated.

Besides the above-mentioned conditions, an injecting solution must fulfil the following requirements:

1. The solution should not be detrimental to the blood or the tissue cells.
2. It should not alter the hemoglobin.
3. It should not produce any distention or contraction of the cells or hemolysis; it must be isotonic. Its freezing-point must be about  $-0.55^{\circ}\text{C}$ .
4. It should contain an accurately determined average amount of the anesthetic.
5. It should not react acid.
6. It should be free from unnecessary or harmful admixtures.

**Temperature of the Solution.**—The temperature of the solution should correspond as nearly as possible to that of the body. The farther we deviate from this optimum temperature, especially on a

downward scale, the greater is the likelihood of irritations resulting. Injections of very cold or hot (above  $+55^{\circ}$  C.) solutions produce serious tissue lesions, usually followed by extremely painful infiltrations. The latter occur also when the solution is not quite sterile, or when the admixtures, especially the suprarenin, have undergone pollution or decomposition.

Recent investigations of Moral have shown that temperature has a pronounced influence upon the anesthetic power of the solution, which should be injected at body heat. Solutions of that temperature have proved to be most satisfactory. This condition can be easily brought about in making a solution from tablets. After boiling, the solution is drawn into the syringe and injected. The operator can readily test the optimum temperature of the solution by touching the barrel of the syringe to the back of his hand.

**Ampoules.**—For the requirements of daily practice it seemed expedient to dispense novocain-suprarenin in ampoules so as to offer the solution ready for use in convenient form. Our experiences with these ampoules, however, induce us to give the preference to solutions freshly made from tablets, for the present at least. The ampoule solution decomposes more quickly, and its stability depends upon the conditions of temperature and light under which it is preserved. Although it is possible to market stable ampoule solutions if all precautionary measures are strictly observed, the manufacture of these solutions is variable and uncertain. Besides, suprarenal extract is not stable for any length of time when in liquid union with novocain.

In medicine, nevertheless, thousands of ampoules are being used daily. We are continually conducting experiments with ampoules, and do not hesitate to confess that, as soon as it becomes possible to eliminate all imperfections, the ampoule solution will be the ideal of convenience for innumerable practitioners. We have employed preparations which were several months old, and upon opening found the solution crystal-clear and no less perfect in regard to anesthetic power than a freshly prepared solution. The process of manufacturing ampoules, however, is not as yet generally perfected so as to guarantee their durability absolutely; especially the technique of

sealing the sterile contents of the ampoule by fusing the neck seems difficult and uncertain, and even first-class laboratories sometimes market ampoules which are unsuitable for use after a very short time, because they are not hermetically sealed. It is probable, however, that the experiments toward improving the technical procedures of sealing ampoules and testing each one in a vacuum will shortly lead to satisfactory and fully reliable results. The small glass splinters which may be produced in breaking the neck of an ampoule, do not seem to constitute a weighty contra-indication, and no untoward consequences from this source have ever been reported. In short, an improvement in the manufacture of ampoules will soon prove their eminently practical value.

Those practitioners who employ ampoule preparations of reliable manufacture should proceed as follows:

Ampoules must be kept as sterile as every other instrument used for injection. The unbroken ampoule contains a sterile solution, yet its outer surface is by no means sterile. It passes through many hands, is packed in ordinary cotton, and should therefore not be used without having been previously sterilized. The operator is cautioned not to nick the neck of the ampoule with a file in order to break it more easily. This measure invites sepsis, and is absolutely unnecessary, even dangerous. From the file numerous infectious bacteria are introduced into the sterile solution after the neck is broken. Ampoules are best sterilized by carefully washing some half dozen in a weak solution of carbolic acid or lysol, drying them and then preserving them in a covered glass jar or tray of dark violet color containing 70 per cent. alcohol. When needed, an ampoule is taken from the alcohol with sterile pincers and laid between sterile gauze or cotton, the neck is broken in the gauze either by hand or by means of a sterile hemostat while inverting the ampoule—an easy procedure—the mouth is carefully exposed, and the contents are drawn out through an iridio-platinum hypodermic needle which has previously been sterilized by passing through an alcohol flame. Experiments have been undertaken in order to ascertain whether in the customary process of opening an ampoule with the beaks of nippers or by holding it in a clean

napkin, the sterile solution can be infected, and to what degree. In these tests the outer surface of the ampoule which contained a sterile solution was not previously sterilized. In all cases the solution was found to have been infected in the opening process. It remained sterile only when carefully manipulated in the manner described.

**Tablets.**—Since the preparation of novocain solution from the powder, with suprarenin added in drops, is not sufficiently reliable and uniformly practicable in daily practice, the use of tablets as in general vogue in surgery is given the preference.

Braun bacteriologically analyzes every year the novocain tablets of a certain drug firm, and finds them always sterile. Some time ago Hoffmann reported that, on analyzing tablets from another drug firm, he discovered that over one-half contained bacteria. Professor Riesel, upon Braun's instigation, analyzed numerous tablets of the first make, all of which were found sterile. Nevertheless there is a possibility of tablets occasionally containing bacteria.

Upon investigation it appears that novocain tablets will keep for years if protected from light and humidity. Failures are due to other causes, such as lack of cleanliness, use of sodium chlorid solution contaminated with bacteria, or rinsing of the syringe with lysol or soda, which causes decomposition of the suprarenin. The physiologic salt solution employed in dissolving these tablets must be absolutely free from soda as this precipitates alkaloids and decomposes suprarenal preparations.

"It was a matter of great importance to find an effective and reliable method of sterilization for these tablets, and Braun, after continued experiments, soon arrived at a practical result. He recognized that the source of decomposition of suprarenin solution invariably lies in traces of alkalis present in the dissolving media, due partly to the alkalinity of glass, partly to other causes. If suprarenin solution is boiled in absolutely non-alkaline sodium chlorid solution or in non-alkaline distilled water, or sterilized by steam, in a non-alkaline glass vessel which has been previously treated with hydrochloric acid, the solution retains its color and full power. These precautions not being feasible in an average dental office, the absolutely

accurate work of a chemical laboratory is required. In our operating rooms, where lots of soap and soda are used, it is impossible entirely to prevent alkaline traces from getting into the solutions; this difficulty, however, can easily be overcome by other means.

"To one liter of the physiologic salt solution to be used in dissolving the tablets, 2 drops of official dilute hydrochloric acid are added. Solutions made from novocain-suprarenin tablets in this slightly acidulated salt solution may then be either boiled or sterilized in steam without losing any of their power. The greater stability of this solution is evident, as no red discoloration at all occurs, or, if any, only after prolonged standing.

"No physiologic effects from this added trace of dilute hydrochloric acid can be noted after injection, especially no tissue lesions. On the other hand, the hydrochloric acid suffices to neutralize the alkaline traces which may be present in the salt solution or in the glass vessels employed, and which invariably remain in syringes and needles boiled in soda solution, even if these are rinsed in water or normal salt solution before use." (Peuckert.)

During the 1912 meeting of local anesthesia experts, held at Münster, it was the consensus of opinion that a freshly made solution of novocain mixed with suprarenal extract immediately before use was most desirable. But even then there is no absolute certainty that the two component parts of the solution, especially the suprarenin, will keep fresh and undecomposed for more than a few days. Even such a simple solution as physiologic sodium chlorid, though preserved in specially constructed stock vessels (see Fig. 2), will not remain sterile for more than two or three weeks. How much less can we then reasonably expect of the stability of such a delicate substance as suprarenin? The best chemical firms invariably warn in their suprarenin circulars in emphatic terms that the stability of sterile suprarenin solutions is best guaranteed by preserving them in the original bottles, saying: "Pouring into dropping-bottles, etc., is contraindicated."

Braun also, who undoubtedly has had widest experience in the question of solutions, says: "The tablet method is the simplest and

most reliable. Outside of large surgical institutions it is the only one which should be recommended. Practitioners should never have solutions of alkaloids made by an apothecary and keep them in a medicine chest until needed. An incalculable lot of damage has been done by such practice." The argument advanced against the tablet method, viz., that it does not allow of modification of the suprarenin admixture, is untenable according to Braun's statement that "the dosage of suprarenin in the infinitesimal doses in which it is employed in local anesthesia is fairly immaterial. These greatly diluted doses must be regarded as absolutely innocuous, provided a pure preparation and fresh, unaltered solutions are used."

Following the Münster meeting we have made thorough experiments in order to ascertain whether Seidel's method of making a solution is superior to the tablet method or not, and we have come to the conclusion that the advantages of adding the suprarenin to every solution made are defeated by the disadvantages inherent in this procedure. In the first place, it is very difficult in daily practice to draw the suprarenin solution into a pipette under all necessary precautions; moreover the suprarenin becomes easily contaminated by the influence of air, light, temperature, dust, etc., every time a few drops are poured out.

For these reasons it does not seem advisable to adopt Seidel's method of preparing the solution in private practice, because it permits of new sources of error. Braun's perfect results with the tablet method in major surgery fully justify its adoption in dentistry. Following Braun's lead, and convinced by our own experiences, we must pronounce the solution made from tablets as the best and safest procedure for dental work. If we wish to individualize our dosage, we simply add 2 tablets E or T to 3 c.c. or 4 tablets to 5 c.c. of Ringer solution, instead of adding 1 tablet E or T to 1 c.c. of Ringer solution. Since, in doing so, we simultaneously reduce the dosage of novocain, we lessen the toxicity of the whole solution, and are in position to avoid failures or untoward secondary effects while retaining the full anesthetic power of the solution. As long as the large doses of suprarenin which are employed in major surgery, and in comparison with which

our dental doses are infinitesimally small, have not produced any alarming symptoms, as a perusal of the literature on this subject has shown, there is no reason to demand a modification of the suprarenin admixture in every individual case.

Aside from theoretical considerations, practical experience has proved that the dilute tablet solution is fully efficient, as can be verified by controls. In order also to test Braun's contention that the doses of suprarenal extract employed for dental purposes are so small as to be innocuous, we have employed 1.5 per cent. and 2 per cent. NS tablets "E" in Ringer solution, in about 500 cases of patients with delicate constitution, serious heart disease, arteriosclerosis, etc. and have not observed one single case of intoxication.

After the investigations described, we fully agree with Braun that as long as the solution, and the injection, etc., are made correctly, the hair-splitting finesses which Seidel indulges in are of no practical significance for dentists. Seidel's own experiences with facio-maxillary injuries during the World War have proved that up to 50 c.c. of 2 per cent. NS solution can be injected with impunity. In short, the tablet method as advocated by Braun is superior to all others and most suitable for dental practice, where further modifications of the solutions are uncalled for, and will merely complicate matters.

**The Solution, its Composition and Preparation.**—Various concentrations of novocain solutions, viz., from 0.5 to 2 per cent., have been recommended for dental purposes. Years of practical experience have shown that it is best to keep the concentration of the novocain as well as the suprarenin as low as has been found practical in the large average of cases. In delicate adults and in children we have had excellent results with 0.5 per cent. novocain solutions, and we are still convinced that the 1.5 per cent. novocain-suprarenin solution is successful in all ordinary and even in the most complicated cases. This is also attested to by the recent reports of Braun, Adloff, and others, who find a 1 per cent. solution always satisfactory, and warmly recommend this concentration. To cite Braun: "I admit that in minor ambulatory surgery it is desirable to have only one solution with which every operation can be made, and that is the 1 per cent. solution."

If we have, nevertheless, advocated the 2 per cent. concentration, this was done because it is not the concentration of the novocain so much which determines the toxicity of the solution as the suprarenin. The 2 per cent. solution can be generally recommended for dental practice without hesitation, so long as it is understood that the concentration limit of 2 per cent. must never be exceeded, while, with some experience, a practitioner may find it practical to reduce the dosage. We would certainly make a plea that the advocates of the 2 per cent. solution should not refrain from trying out the 1 per cent. and 1.5 per cent. solutions, which they will surely find fully successful after some trials. NS solutions of more than 2 per cent. concentration are contraindicated in nerve blocking, owing to the greater toxicity of such solutions, locally up to 3 c.c. of a 4 per cent. solution may be employed provided the tissues are healthy. Injection into an infected area may cause a dissemination of pathogenic bacteria into the blood and lymph channels leading to general sepsis.

The efficacy of a solution depends upon its proper composition, perfect isotonia and sterilization before injection. The isotonia of a solution and its optimum rapidity of absorption in the tissues are insured by the addition of from 0.65 to 0.92 per cent. chemically pure sodium chlorid. For the 1.5 per cent. novocain solution, a NaCl content of 0.7 per cent. seems best indicated.

**The Ringer Solution.**—Professor Gürber, Director of the Pharmacologic Institute of Marburg University, has for years been making experiments regarding the behavior of calcium salts added to the injected solutions. Upon his instigation chiefly we have substituted a modified Ringer solution for the normal salt solution, and clinical evidence has shown that the addition of calcium salts is not only absolutely innocuous, but most favorably influences the process of absorption of the solution in the tissues. In this respect a considerable improvement has been noted as compared with simple sodium chlorid solution, and further tests have suggested also a theoretical proof of this observation. Calcium undoubtedly has an important function. A trace of calcium suffices, for instance, to increase the vital function of the leukocytes, the salts of calcium being of prime importance in phagocytosis and in resistance to infectious diseases.

Calcium chlorid 0.05 per cent. produces a stimulation in phagocytosis of about 22 per cent., 0.1 per cent.  $\text{CaCl}_2$  one of 45 per cent., while 0.25 per cent.  $\text{CaCl}_2$  decreases again the phagocytic action of the leukocytes.

Owing to its easy oxidability, calcium does not occur free in nature, but in the form of calcium ions it probably plays an essential part in the chemical and electrolytic processes of the human organism. Its oxid, again owing to its great affinity for acids, occurs in the body only in form of a salt, while the calcium salts in turn seem to combine with various proteids.

Of special significance in this question of the action of calcium salts upon the cells and tissues is the fact that besides the calcium ion no other substance is capable of increasing the phagocytic action of the leukocytes. Hamburger has thus ascertained the following phenomena:

1. If the heart of a turtle, which in a moist medium will continue to beat for a long time, is immersed in a pure sodium chlorid solution, the beats cease immediately. Sodium chlorid, therefore, evidently exerts a toxic action upon the heart. If, however, a minute trace of calcium is added, the heart at once begins to beat again.

2. If a trace of calcium is added to a sodium chlorid infusion the collapsing human heart almost immediately begins to work more vigorously, and the blood-pressure rises higher than it would if simply a sodium chlorid infusion were used.

The presence of calcium ions counteracts the toxic influence of pure sodium chlorid solution and stimulates the heart action. From these observations internal medicine has adopted the practice of adding calcium to every infusion.

Although pure sodium chlorid solution apparently does not exert as pronounced a toxic action upon the phagocytes as upon the heart and intestines, nevertheless a slightly toxic effect is demonstrable, according to Sticker, the phagocytic power of the leukocytes being impaired. Calcium therapy plays also a surprisingly important role in infectious diseases, since calcium ions, if added to a vaccine, have a stimulating action upon the functions of the heart and the

leukocytes, as for instance in diphtheria, pneumonia, and especially in tuberculosis. It has long been known that workers at lime-kilns who continually inhale liberal quantities of dust from burned and slaked lime rarely suffer from tuberculosis. In febrile conditions, the antipyretics administered by no means counteract the usually concomitant diminution in the alkalinity of the blood (Klemperer), but here again calcium therapy is employed to greatest advantage, being a purely physiologic, hence natural, method of treatment free from untoward secondary effects.

In connection with these findings, the Viennese scientists, Chiari and Januschke, have ascertained that soluble, neutral calcium salts exert a remarkably antiphlogistic action. According to Leo it seems certain that "the calcium ions in the human organism serve as solidifying agents, and their presence is indispensable especially in the enzymotic processes leading to the coagulation of fibrin and casein. The observation that only infinitesimal quantities of calcium are necessary to produce the coagulation even of large quantities of blood or milk seems to explain why such minimal quantities of calcium as are conducted to inflamed tissues by the circulation following subcutaneous injection can exert such a marked effect."

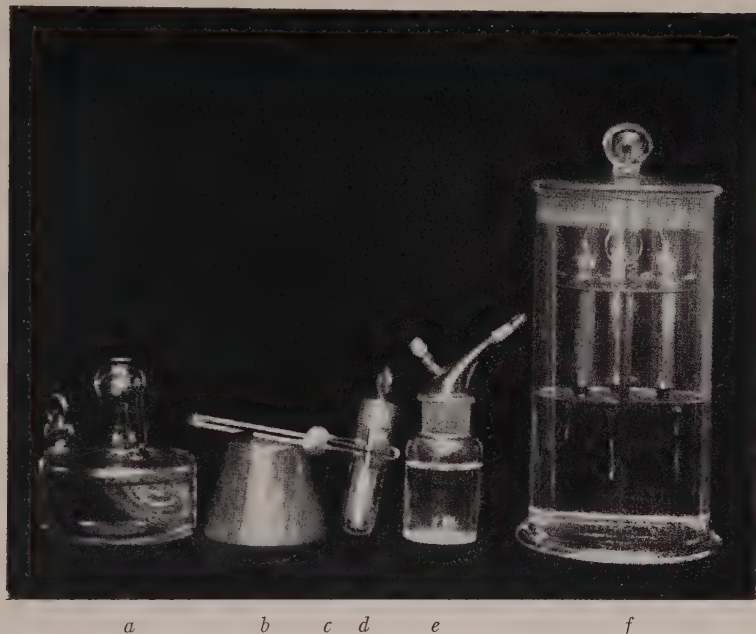
Leo has made control tests of the antiphlogistic properties of calcium salts in pneumococcic and other infections, all of which proved positive. The selection of the bacteria in these tests was immaterial, "since the action of the calcium salts is not directed against the phlogogenic organisms themselves, but these salts serve to strengthen the resistance of the tissues against the influence of phlogogenic organisms without influencing these directly." Leo has shown that small quantities of calcium chlorid, viz., 1 c.c. of a 2.5 per cent. solution, can be injected hypodermically in man without producing local or systemic lesions. In inflammations of mucous membranes, as in the mouth, Leo recommends rinsing with 2 per cent. calcium solution.

From the above brief account, the importance of calcium salts in our special field becomes evident. It is only natural that we should utilize the wonderful properties of the calcium ions in the hypodermic

injection of anesthetics in order to limit to a minimum the possible untoward sequelæ of injections. In every injection we produce a tissue lesion by the insertion of the needle; the tissue itself is inundated with a foreign fluid, and a temporary change is produced in the metabolism by the elimination of the sensory organs. Under normal conditions, and if all necessary precautions have been taken, this condition of the tissue is usually, though not always, tolerated with impunity, the solution is fully absorbed, and the temporarily altered tissue quickly resumes its normal function. In cases of acute inflammation or suppuration, however, the elimination of sensation is not tolerated so indifferently, absorption seems retarded, edema forms frequently, and even after-pain may occur. In such cases the sodium chlorid base as formerly employed seems to approach the ideal, though even then the untoward secondary effects described could not always be entirely avoided despite perfect technique, solution, and diagnosis. The calcium chlorid base, however, as we are now employing it in the form of the Ringer solution, has proved superior to the pure sodium chlorid base, in fact, ideal for local injection. The calcium salts in combination with the other salts insure surprisingly perfect absorption even in the most difficult cases, increase the penetrating action, and, in surgical cases, contribute materially to rapid and uneventful wound healing. Rinsing with 2 per cent. calcium chlorid solutions favorably influences and accelerates healing in the oral mucosa; lime water should, therefore, be given a thorough trial in all inflammatory conditions of the mouth. The advantages of the calcium chlorid base are so convincing, and clinically so evident, that it is surprising the Ringer base has not long been tried in connection with local injections, considering the fact that for quite some time all infusions have been prepared with an admixture of calcium. Why should we cling to the time-honored "physiologic salt solution" in interventions which necessitate the direct inundating of the tissues with foreign solutions? Everyone will agree that the sodium chlorid solution is by no means cognate to the cell and strictly "physiologic," since it lacks an important constituent which the cell requires for normal metabolism. These constituents—namely, calcium chlorid, potassium

chlorid and sodium bicarbonate—have been determined by Ringer several years ago. Of these salts we have omitted the sodium bicarbonate as being an extremely unstable body. This omission is in no way detrimental to the effect of the solution, because, for the improvement of absorption, calcium chlorid is of chief importance.

FIG. 2



Instrumentarium for tablet solution. *a*, alcohol lamp; *b-d*, graduated test tube of Jena glass for boiling solution, with holder and wood stand; *e*, Ringer stock flask; *f*, jar for preserving syringes.

Since the summer of 1912 we have combined all imaginable percentages of local anesthetics with Ringer solution, and have noted in all cases an improvement both in the anesthetic action and the after-effects as compared with pure sodium chlorid solutions of these anesthetics. In severe purulent conditions, in which the sodium chlorid solution used to produce edema, after-pain, and disturbances in the healing process, all secondary effects were either surprisingly trivial or entirely absent. In simple injections, as a rule, no untoward sequelæ were observed.

From these considerations we would advocate a novocain solution of the following composition:

|                                   |                   |
|-----------------------------------|-------------------|
| Novocain . . . . .                | 1.0 or 1.5 or 2.0 |
| Sodium chlorid' . . . . .         | 0.5               |
| Calcium chlorid . . . . .         | 0.04              |
| Potassium chlorid . . . . .       | 0.02              |
| Sterile aqua destillata . . . . . | 100.0             |
| Synthetic suprarenin . . . . .    | 0.002             |

FIG. 3



Flask for Ringer solution and porcelain cup for preparing and sterilizing novocain-suprarenin solution.

Besides calcium chlorid various admixtures have been recommended for enhancing the action of NS solutions, such as sodium bicarbonate and potassium sulphate. The latter undoubtedly influences the intensity of the local effect of novocain, so that the admixture of 0.4 per cent. potassium sulphate is commendable. Potassium sulphate, however, can be used only with normal salt solution, not with

a Ringer base with which it forms insoluble compounds. Braun employs the following NS solution with calcium sulphate admixture:

|                                |            |
|--------------------------------|------------|
| Novocain . . . . .             | 1.5 to 2.0 |
| Sodium chlorid . . . . .       | 0.7        |
| Potassium sulphate . . . . .   | 0.4        |
| Aqua destillata . . . . .      | 100.0      |
| Synthetic suprarenin . . . . . | 0.002      |

**Preparation of the Solution.**—The NS tablets most suitable for dental practice are as follows:

NS tablet E containing novocain, 0.002 gr., suprarenin, 0.00005 gr.

NS tablet T containing novocain, 0.02 gr., suprarenin, 0.00002 gr.

NS tablet H containing novocain, 0.06 gr., suprarenin, 0.00015 gr.

The solution is best made from novocain-suprarenin tablets and a Ringer stock solution. The instrumentarium required for this purpose consists of a stock flask (see Figs. 2 and 3), which serves for the preservation and gradual consumption of the Ringer solution under sterile conditions, and a small test-tube, graduated to 8 c.c., both made of Jena glass. The test-tube rests upon a secure wooden stand and is held with a pair of tweezers while boiling the solution. The stock flask holds 50 c.c., and is constructed in such a manner that, without removing the glass stopper, the desired quantity can be poured off through a tapering glass nozzle, air being admitted through a small side opening which is sealed with a wad of cotton. Various modifications of this stock flask and dissolving test-tube are now in the market. After this stock flask, together with the rest of the instrumentarium, has been sterilized in boiling distilled water for ten minutes, it is filled with the following modified Ringer solution:

|                             |       |
|-----------------------------|-------|
| Sodium chlorid . . . . .    | 0.5   |
| Calcium chlorid . . . . .   | 0.04  |
| Potassium chlorid . . . . . | 0.02  |
| Aqua destillata . . . . .   | 100.0 |

The correct proportions of this modified Ringer solution are best insured if the operator makes it himself from the Ringer tablets manufactured by a few reliable drug firms, 5 of these tablets dissolved in 50 c.c. of aqua destillata giving the correct solution.

The filled stock flask is closed and its contents are boiled for ten minutes in a distilled water bath, preferably in a small electric boiler which is best suited for disinfection in local anesthesia, and must always be fed with distilled water. In order to prevent the stock flask from breaking during the process of sterilization, it is best to tie around it a sterile mouth napkin. Electric sterilizers, which are so constructed that the heating element dips into the water, are unsuitable for this purpose. In regard to the use of distilled water, it goes without saying that only *aqua destillata* should be used in making up a solution. Boiled water is by no means sterile; moreover, it may contain quantities of alkalies, these varying in different districts, which detrimentally affect the solution, as will be indicated by a pink or rose discoloration. Even the *aqua destillata* as bought in pharmacies is by no means reliable, as everyone familiar with the slipshod methods by which it is made—usually in the darkest spare corner, and frequently by none too careful or skilled clerks—knows very well. It frequently contains bacteria that have been introduced from the air or the dust collected on the large bottle in which it is kept, and on close scrutiny is often found to have particles of dust, filter paper, or even hair, suspended in it. The acquisition of a small filter apparatus will therefore prove a boon to the conscientious operator, and in a busy and clean practice will soon pay for the initial investment, especially since *aqua destillata* must be used for the sterilization of the instrumentarium employed in connection with local anesthesia.

It is a fact known to every chemist that glass, which is more or less strongly of an alkaline nature, is dissolved by cold and hot water, and these traces of alkali, however minute, seriously affect the stability of suprarenal preparations. Some operators for this reason employ only the scientifically manufactured brown non-alkaline glassware of the Jena glass works. How sensitive to alkalis the suprarenal preparations are is strikingly illustrated by a report of Dr. E. Paul.<sup>1</sup> He found that, four weeks after purchase, the contents of an unopened

<sup>1</sup> Deutsch. Zahnärztliche Woch., February 10, 1912.

bottle of suprarenin manufactured by a reputable drug firm had become turbid.

For reasons similar to those given in favor of the preparation of aqua destillata by the operator himself, the purchase of prepared Ringer solution is undesirable. The purchased product often contains impure drugs in incorrect dosage and slight traces of soda. A purchased Ringer solution should always be tested for alkaline traces; if present, the alkalis must be neutralized by the addition of one drop of one-tenth dilute hydrochloric acid, which compensates at the same time for the alkalinity of ordinary glass containers and prevents the catalysis of oxygen in the anesthetic solution, either of which unfavorably influences the suprarenin.

The Ringer solution is best filtered into the stock flask through sterile filter paper. All the salts in the solution must be chemically pure. The quantity of Ringer solution required in a given case is poured out into the previously sterilized test-tube of Jena glass after removing the little glass hood from the nozzle. This method prevents the invasion of microorganisms from the surrounding air almost entirely, and insures the sterility of the solution for a longer period of time. The poured-off quantity should always be slightly greater than is absolutely needed, because in boiling a small fraction of the solution is lost by evaporation. The test-tube is grasped with the tweezers, and the Ringer solution boiled for a few seconds over an alcohol flame. The use of a Bunsen gas burner is not advisable, as the combustion is not always perfect, and undesirable particles of soot are carried into the solution and deposited upon the iridio-platinum needle in sterilizing.

Into the hot Ringer solution, the novocain-suprarenin tablets are thrown with sterile pincers, 1 tablet E or T in 1 c.c. of Ringer solution giving a 2 per cent. novocain-suprarenin solution. After adding the necessary number of tablets, the solution is once more raised to boiling-point, and the hot, closed test-tube is set upon the wooden stand at an angle of 45 degrees. The sterile syringe, through which hot distilled water has been drawn several times, can now be conveniently filled by drawing up the solution through the iridio-plati-

num needle, which has previously been passed through the alcohol flame. The solution, which has in the meantime cooled to body temperature, is at once injected.

There are in the market small graduated porcelain cups of two sizes, holding 3 and 10 c.c. of solution respectively, with convenient metal stands and handles, which are extremely practical for preparing the tablet solution, and appreciably simplify the instrumentarium (see Fig. 3).

It has been observed that some operators fill their dissolving cup with Ringer solution, add the novocain-suprarenin tablets to the cold solution and boil. This procedure is reprehensible because the tablets come in almost direct contact with the flame at the bottom of the cup where they are roasted, as it were, long before the Ringer solution approaches boiling point. Such combined roasting and unduly prolonged boiling greatly impairs the clearness and stability of the resulting solution.

If novocain-suprarenin solution is prepared by the procedure above indicated, it will always be fresh and crystal clear, possess body temperature, and fulfill all reasonable requirements of an anesthetic solution. If one wishes to reduce the concentration, 2 instead of 3 tablets E or T in 3 c.c., or 4 tablets E or T in 5 c.c., of Ringer solution are employed. The ease with which solutions can be modified according to the operator's judgment and the requirements of the case, is demonstrated in the affixed table:

TABLE OF MODIFIED SOLUTIONS

| Quantity of Ringer solution.    | Number of tablets.       | To make a concentration of |
|---------------------------------|--------------------------|----------------------------|
| 1 cc of Ringer solution . . . . | 1 tablet E or T . . . .  | 2.0 per cent               |
| 3 cc of Ringer solution . . . . | 2 tablets E or T . . . . | 1.5 per cent               |
| 2 cc of Ringer solution . . . . | 1 tablet E or T . . . .  | 1.0 per cent               |
| 3 cc of Ringer solution . . . . | 1 tablet E or T . . . .  | 0.7 per cent               |
| 4 cc of Ringer solution . . . . | 1 tablet E or T . . . .  | 0.5 per cent               |

As a precaution, freshly made solutions should always be protected immediately from light by a cover of ruby-colored glass, unless the entire quantity of solution is used at once. A solution which after standing for more than thirty minutes is no longer entirely clear

should never be used. Even the slightest discoloration indicates decomposition of the suprarenin and may produce untoward sequelæ, though it may not impair the injection. It is far better to make several fresh solutions than to use one that has been standing for some time. We always use up the quantity calculated for a case, and prefer to make several fresh solutions rather than employ a stock solution. This precaution has been fully justified by the invariability in the certainty and safety of our results.

Failures are not due to the solution only. As we have seen, to render an injection perfect in all its phases many factors are to be considered individually. To recapitulate briefly: solution, glassware, syringe, needles and field of operation must be absolutely sterile; the solution, moreover, must be of optimum composition; the time of waiting before proceeding to operate must be correctly gauged under due consideration of the normal and pathological anatomy of the field of operation; and last but not least, the technical execution of the injection must be governed in every case by a correct interpretation of the conditions presented. In addition, the physical constitution of the individual patient must be subjected to a rigid examination. Is it a wonder, then, that the criticisms of local anesthesia vary so greatly, when, owing to the complicated nature of the technique—which, however, after some practice becomes simple routine—the neglect of one single postulate suffices to impair the desired effect and to produce partial or total failure, which unskilled and careless operators are usually too prone to attribute to the anesthetic solution itself?

**Combination Tablets of Novocain-suprarenin and Sodium Chlorid Contraindicated.**—For the purpose of simplifying the preparation of isotonic solutions, several drug houses are marketing compound tablets of novocain, suprarenin, and sodium chlorid. In tests of a great many of these tablets from different manufacturers, it was found that they give discolored solutions within a very short time after purchase, especially when the tube has once been broached, proving that the combination of novocain-suprarenin and sodium chlorid is very unstable.

**Maximal Dose.**—It is almost impossible to fix the maximal dose of novocain because, as Braun remarks, the toxicity of this agent depends as much upon the concentration and the manner of employment of the solution as upon the dosage. For surgical purposes, from 0.5 to 2 per cent. solutions are usually employed in combination with suprarenin. Nast and Kolb have injected up to 50 c.c. of a 1 per cent. solution, Axhausen up to 170 c.c., and in one case as much as 200 c.c., *i. e.*, 2 grams of the drug. Of the 1.5 per cent. solution Borchardt has administered up to 150 c.c., Hesse up to 220 c.c., Braun from 100 to 200 c.c., in some cases even 250 c.c., *i. e.*, 1.5 grams of the drug. Excepting occasional vomiting immediately following injection, surgeons have not noted any untoward sequelæ from these doses, hence Braun's statement that "of these 0.5 to 1 per cent. solutions it is permissible to inject as large quantities as are necessary in a given case for the local anesthetization of the field of operation."

The opinion that the healing process following dental operations may be disturbed by local anesthesia is to be regarded as erroneous. From the foregoing considerations it will be admitted that novocain is an ideal anesthetic which has greatly enhanced the safety of local anesthesia owing to the possibility of injecting with impunity large quantities of most efficacious anesthetic solutions.

### THE INSTRUMENTARIUM.

The instrumentarium selected for local injections should fully comply with all modern rules of asepsis and should allow of any form of sterilization, especially boiling.

**The Syringe.**—The selection of a suitable syringe, this most important instrument, has always involved the greatest difficulties, because syringes with leather piston, which are the tightest, cannot be subjected to steam, while most glass-and-metal, all glass, or all metal syringes do not possess hermetically fitting pistons. After examining a great number of models, we have designed, with the assistance of Freienstein of Berlin, a syringe which has fulfilled all the necessary requirements.

In view of the thorough tests of the past few years this syringe has indeed surpassed all expectations, and has proved superior to all other partly antiquated models which are advertised for dental purposes.

This syringe is made of glass and metal, and is constructed so as to avoid all minute furrows and corners which catch dirt and are difficult to clean (see Fig. 4). The entire outer surface of the syringe is uniformly round and smooth. The metal piston is made accurately so as to fit tightly in the glass barrel, and terminates in a crutch-shaped handle, so that it can be conveniently laid against the ball of the thumb and firmly braced there. This handle, being threaded and fastened in a screw socket, can be shortened or lengthened at convenience. To allow for the exertion of such pressure as is necessary for injection, two wing-like, strong, and milled finger rests are fitted to the metal sheath of the syringe barrel; these finger rests are a little smaller in the 1 c.c. syringe than in the larger size. For practical reasons this syringe is made in two sizes, one holding 1 c.c., the other 2 c.c. of solution. On the glass barrel a scale is etched for gauging the contents. The 2 c.c. column of liquid being graduated to 40 lines. After some time, viz., after from three to six months of continual use, the piston wears and should then be replaced, as it loses its required tightness. It is best always to keep three or four syringes of both sizes on hand—a luxury which will pay in the end.

The new model is somewhat longer and thinner than the old, and has been considerably improved in regard to asepsis by the following new features:

A smooth, beveled cone "K" is screwed over the threaded tip of the syringe, hermetically protecting the hubs B, C or F and the upper portion of the barrel, so as to prevent contamination by saliva, blood, pus, etc., and to safeguard the sterility of the syringe and its contents.

The threaded syringe tip as well as the upper ends of the extension attachments D, E and F are countersunk producing such close fit of the needle cone that the needle is accurately centered and the soft metal core cannot expand and jam even upon severe tightening.

The extension attachments D, E and F have a soft metal jacket

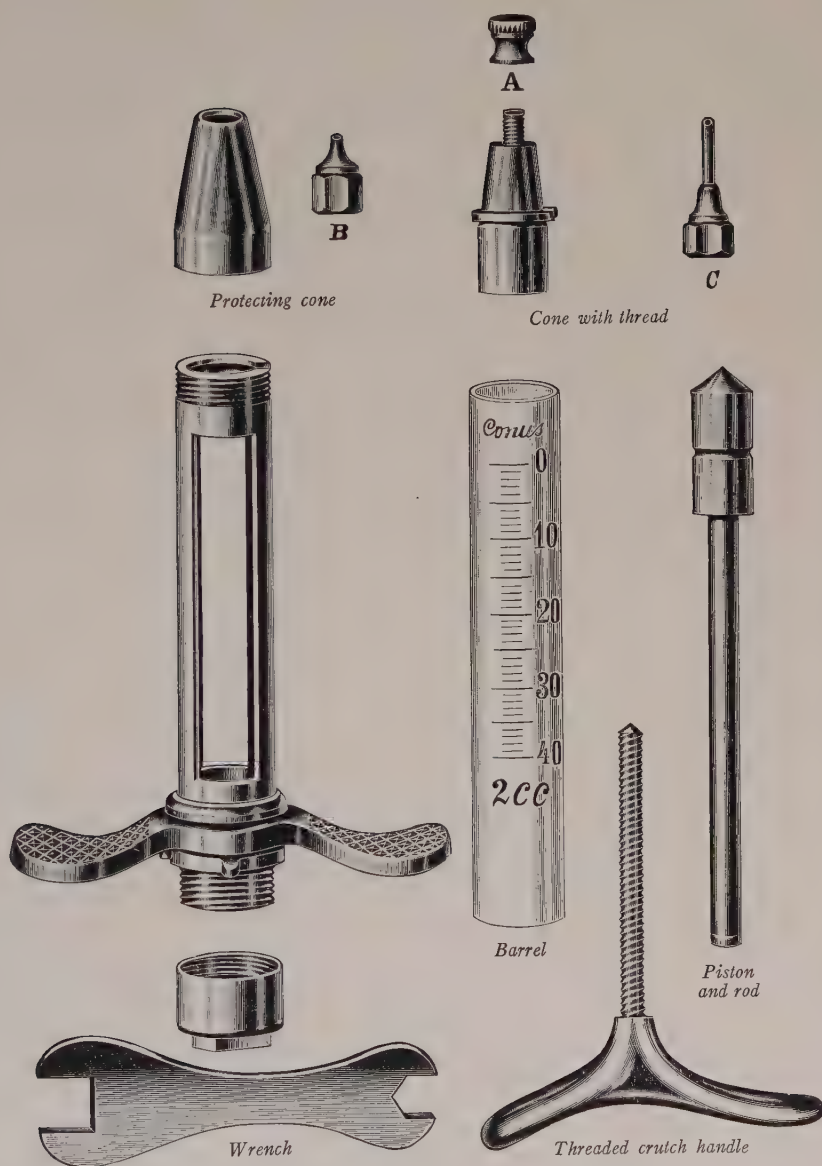
FIG. 4a



2 cc syringe (natural size.)

Glass and metal syringe model 1920. K, closing cap; A—F, hubs.

FIG. 4b



Syringe model 1920 disassembled, ready for boiling.

which adapts itself to the syringe tip thread as tightly as do the exchangeable needles, doing away with unsatisfactory leather or rubber washers.

The finger rest (cross bar) is so constructed that it moves only part of a turn, insuring its firm fixation and ease in taking the syringe apart (Fig. 4a).

Before drawing fresh solution into the syringe, the protecting cone K is removed and sterilized, and replaced after the syringe has been filled.

Such tried and proved features of the old model as the stout and gnarled finger rest, the extensible piston rod with crutch handle that snugly fits the ball of the thumb have been retained in the new model. All minute furrows and corners which catch dirt and are difficult to clean have been avoided.

The conical head of the piston fits into a corresponding recess in the metal head which is ground to fit the glass barrel so that air bubbles can be readily ejected. This exchangeable metal head renders the syringe especially aseptic as after its removal the glass barrel can be thoroughly cleansed; circular washers or fixed metal parts are always dirt traps.

Syringes with asbestos pistons are less aseptic and durable than those with metal pistons since the asbestos soon frays and crumbles requiring frequent renewal. They must be preserved in a neutral sterile solution as in a dry state they do not fit tightly and cannot be used. Owing to its hygroscopic property, asbestos absorbs liquids which must be thoroughly bleached out by boiling in order to guarantee the purity of the solution.

All-glass syringes, besides many advantages, have the one great disadvantage that their pistons cannot be ground accurately enough to fulfil dental requirements. Moreover their material and construction is not durable enough to withstand sufficient pressure.

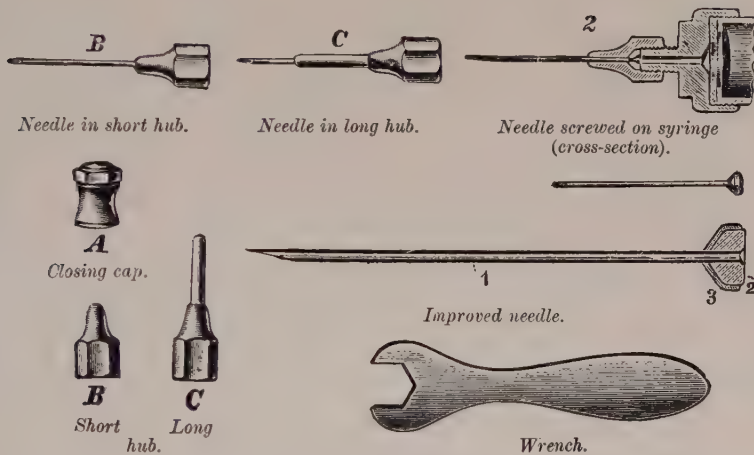
All-metal syringes are unsatisfactory as the solution within the barrel is out of sight and beyond control.

Even in all-glass-and-metal syringes, the metal pistons cannot be ground absolutely tight, so that, under strong pressure, some solu-

tion will regurgitate behind the piston. Nevertheless these syringes have for years proven most satisfactory. After some use, metal pistons will wear and must then be replaced by new glass barrels and pistons.

The syringe should be taken apart once daily and sterilized by boiling. The parts are laid upon gauze in cold distilled water which contains no soda and boiled. After actually boiling ten minutes, the sterilizer is allowed to cool and the parts are taken up with a sterile cloth and assembled with sterile pliers.

FIG. 5



Needles, hubs, and wrench for injection syringe, designed by Dr. G. Fischer.

**Needles.**—The needles selected by us possess the following details of construction: 1, the hollow needle, either of seamless steel, pure nickel, gold or iridio-platinum; 2, body of soft metal for firmly tightening the needle upon the orifice of the syringe; 3, conical shell of hard metal, open below, from which the soft metal core protrudes. This arrangement remedies the deficiencies of the old style needles in which the unprotected soft metal cone could not stand much use, became flattened easily, and jammed in the hub so firmly that both hub and needle had to be replaced, which was rather expensive when gold or iridio-platinum needles were used. The new needles are attached to

the syringe absolutely tightly by inserting the needle in one of the hubs (*B* or *C*) and screwing it firmly on the orifice of the syringe. In order to enable practitioners with sensitive fingers to manipulate the hubs easily, which heretofore were milled, the hubs *B* and *C* are made with hexagonal connections, so that they can be conveniently and firmly tightened by a slight turn of the wrench. No force should be used, otherwise the soft metal cone of the needle becomes unnecessarily worn.

FIG. 6



Thin needles for dental practice: No. 1, length, 42 mm. with long point; diameter 0.9 mm.; No. 17, *a*, length, 23 mm.; *b*, length, 26 mm.; *c*, length, 42 mm.; diameter, 0.47 mm.; No. 18, length, 16 mm.; diameter, 0.42 mm.

**Steel Needles.**—For our purpose the needles No. 17, with short points (see Fig. 6), are employed. The needles Nos. 1 and 18 (see Fig. 6) are designed for special purposes, as follows: No. 1 (diameter 0.9 mm.) which is preferred by Williger, for mandibular anesthesia; No. 18, for subperiosteal injection, if a specially short needle is desired.

The three needles No. 17 have a diameter of 0.47 mm., *a* being 23 mm., *b* 26 mm., and *c* 42 mm. long. In contradistinction to other needles, the needles Nos. 17 and 18 are ground short bevel (Fig. 6), which are indispensable if the needle is to come into direct contact with the bone. Long and tapering needle-points are not suitable, because they easily get stuck in the periosteum and bone, break or bend and cause complications. In mandibular anesthesia, however, where the needle is advanced along the bone, we prefer needle No. 2.

Besides the thin needles No. 17, the following sizes are used in conduction anesthesia (see Fig. 7):

No. 1.—Needle for tuberosity injection; length, 4.2 cm.; thickness, 0.55 mm.

No. 2.—Needle for mandibular injection; length, 5 cm.; thickness, 0.7 mm.; reinforced in the middle to indicate proper distance of advance.

No. 3.—Needle for Record syringe for extra-oral injection; length, 8 cm.; thickness, 0.7 mm.

These long needles are really suitable for all conduction anesthetics and for extensive infiltrations of several adjoining teeth. For infiltration of single teeth the short needle No. 17 is preferable.

FIG. 7



No. 1. Long stout needle for deep injections.



No. 2. Reinforced needle for mandibular injection.



No. 3. For extra-oral injection, fitting Record syringe.

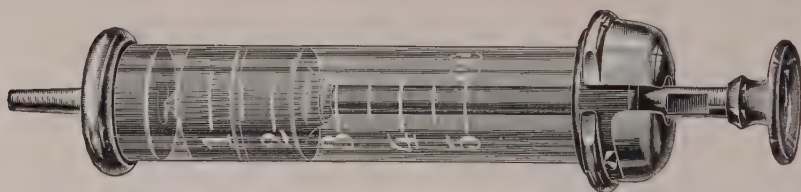
Whenever possible a new steel needle should be used, since needles which have not been perfectly dried after use rust and break. By repeated use the needle becomes dull and unfit. It is a good plan to employ one needle for one day's work, and discard it. After finishing a case, the needle is drawn several times through absolute alcohol and its lumen vigorously blown out with a hot air syringe; a small wire is then introduced, and the needle is boiled and laid in a dry test-tube ready for the next injection.

The steel needles have been so improved by Freienstein that they can be firmly locked in the hubs, and hermetical closure during the injection is guaranteed (see Fig. 5, No. 2). The cone of soft metal is protected by a hard metal case of heavily gilded copper; it

is open below, so that, even under firm pressure, flattening of the soft metal cone and sticking of the needle in the hub are prevented. This arrangement also insures the exactly central position of the needle and prevents all possibility of leakage (see Fig. 5).

**Iridio-platinum Needles.**—The use of iridio-platinum needles cannot be too strongly advocated, because they can be sterilized in a flame before and after use, and do not break so easily. They possess sufficient elasticity to allow the operator to remain in constant contact with the bone, as, for instance, in advancing to the inferior dental foramen. If excessive pressure is exerted or unusual resistance is met with they give and bend; but this is a minor disadvantage as compared with breaking, which may happen with steel needles. Once mounted, an iridio-platinum needle, so long as it is perfect, may remain upon the syringe for months; it will not rust or wear out quickly with use, and is therefore cheaper and more reliable than steel needles, which must be new.

FIG. 8



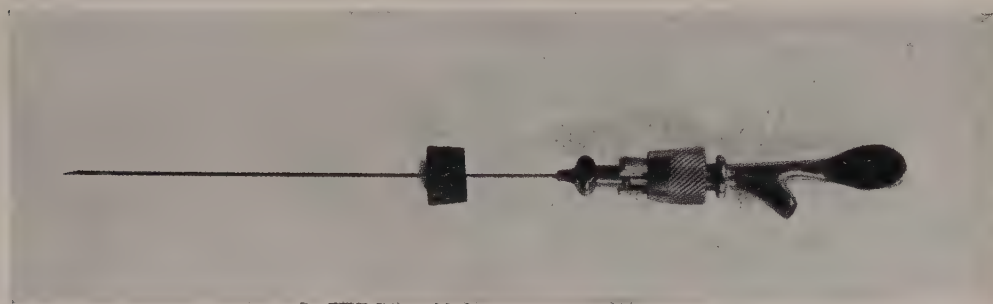
Record syringe, holding 5 c.c. Needles are mounted by push contact, not screwed on.

The finer the needles the smaller will be the injuries caused by their insertion into the tissues and the risk of subsequent infection. For infiltration, therefore, the thin needle No. 17 is most suitable, while for all deeper injections heavier needles are preferred. The resistance to breakage diminishes in proportion to the length of a fine needle; Williger, therefore, advocated heavy needles to overcome this drawback. The 42-mm. needles No. 17, heretofore advocated by us, have been replaced by stouter ones of 50 mm. length and 0.7 mm. thickness (Fig. 7, 2). Since needles always break at the orifice of the hub, a needle should never be inserted to its full length down to the hub. The needles now in use are reinforced at the point to where

they are to be introduced into the tissues, which insures a valuable guide and safety feature in mandibular injection.

For extra-oral injections, Record syringes (Fig. 8) are preferred with suitable long push-contact needles. In order to mark the depth of insertion, Braun recommends a piece of cork (Fig. 9).

FIG. 9



Needle holder with cork disk after Braun.

**Treatment of the Syringe.**—The syringe is best kept in a tall vessel with stand (Fig. 10), containing two parts absolute alcohol and one part of chemically pure glycerin. This solution remains sterile and does not attack the metal parts. In time, fine metal precipitates appear in the sterilizing solution in the shape of a greenish deposit at the bottom of the jar. The solution should, therefore, be renewed every three months. These precipitates can be prevented by putting a small piece of aluminum plate in the bottom of the jar. This also prevents oxidation of the metal parts of the syringe, and keeps steel needles free from rust for some time.

The alcohol-glycerin solution is preferable to lysol, formalin or other solutions. Lysol especially gums up the syringe in a short time and renders it unfit for use.

Before and after use, hot distilled water is drawn into the syringe several times, the iridio-platinum needle is sterilized in a flame, and the syringe and needle are returned to the glass jar (see Fig. 10). It is best to have the syringe dip into the alcohol-glycerin mixture down to the hub. For washing off the alcohol and glycerin, distilled water alone should be used, since alkaline water precipitates novocain and renders the solution ineffectual.

In this connection Riethmuller<sup>1</sup> writes: "The syringes, with hub and needle attached, are best kept suspended in an upright glass jar filled with absolute alcohol and fitted with a German silver

FIG. 10



Glass jar with metal stand (old model) for preserving syringes in a sterile alcohol-glycerin solution. A small aluminum plate kept in the solution greatly reduces oxydation of metal parts.

stand, or better a glass platform, to prevent dulling of the needle point by resting on the bottom of the vessel. The jar is covered with a flat glass cover with ground edge, which is vaselined, and this cover

<sup>1</sup> Dental Cosmos, February, 1913.

is kept tightly on the jar overnight by binding it down with strips of adhesive plaster to prevent evaporation of the alcohol. The flat cover is preferable to one of ground glass, which sometimes is very difficult to remove. Alcohol of 70 per cent. has been found more strongly bactericidal than absolute alcohol; still, absolute alcohol may be preferably used as it soon absorbs enough water from the atmosphere to approximate it to that alleged optimum percentage. In the Bardet syringe sterilizer, which is used by some operators, only the needle is kept sterile by immersion in lysol, while the greater portion of the barrel and piston are exposed to undesirable contamination with microorganisms from the air.

"On removing the syringe from its alcohol bath, some of the alcohol is drawn through the needle and barrel, pressed out and burnt off by passing through a flame.

FIG. 11

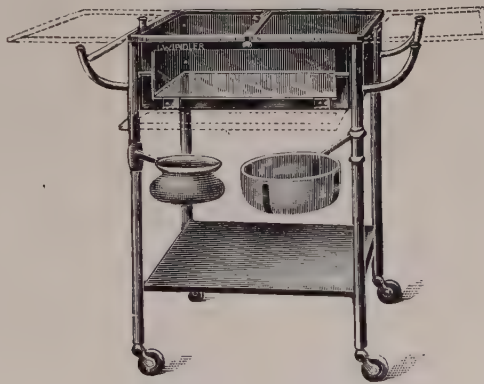


Table for instrumentarium.

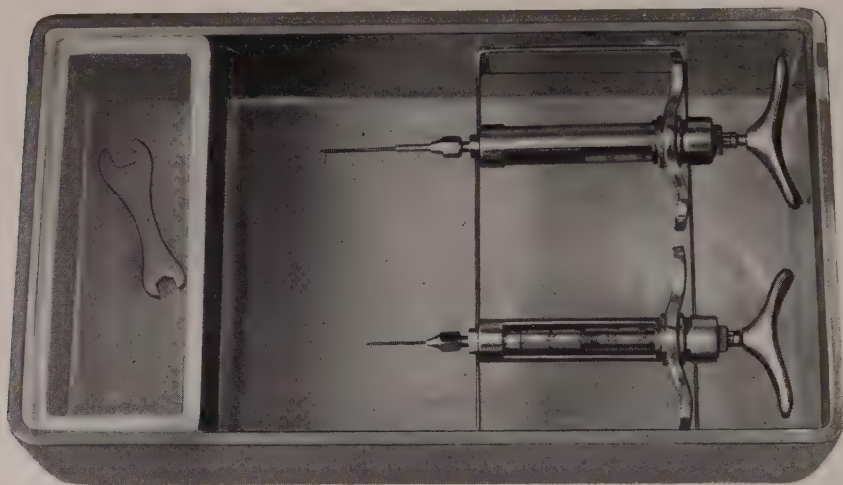
"After the alcohol is burnt off, hot water is drawn into the syringe, as any trace of alcohol which is not thus removed would produce anesthesia lasting several days, as is appreciated by anyone familiar with the treatment of trifacial neuralgia by alcohol injections. The hot water also heats the syringe, and prevents the anesthetic solution from cooling below blood temperature."

The entire instrumentarium is best kept on a suitable table (Fig. 11).

For protecting the syringe from contamination or the needle-point from becoming dulled accidentally, a glass tray is fitted with a

metal inset which accommodates two filled syringes mounted with short or long needles. This tray also holds a small glass tray with ground cover, in which needles and wrench may be kept in an antiseptic solution (see Fig. 12).

FIG. 12



Glass tray with metal inset, accommodating two filled syringes with long or short needles; also smaller covered tray for preserving wrench, needles, pulp broaches, etc., in antiseptic solution. (After Riethmuller.)

### DISINFECTION OF THE FIELD OF OPERATION.

**Asepsis in Injecting.**—As the injection generally precedes surgical intervention of some sort, it plays a part in the subsequent healing of the wound. For this reason, even if a very minute quantity of anesthetic solution is injected, full attention must be paid to asepsis, as untoward sequelæ may arise from neglect of one of the factors involved. Many cases of edema following injections are attributable to insufficient asepsis, such as neglect in sterilizing the hands, the instruments, the solution, or the field of operation.

It is imperative to sterilize not only the instruments and the operator's hands before making an injection but the oral mucosa, which is always infected, must also be subjected to a most thorough and careful sterilization. Among disinfectants, iodine occupies a pre-

dominant place. Disinfection with iodin (iodobenzin) has been generally adopted in modern surgery, where hardly any incision in the epidermis is made without previous swabbing with iodin. This antiseptic not only possesses a deeply penetrating power but also produces dryness of the swabbed area, which is of special advantage in the oral cavity.

Tincture of iodin (tincture of iodin and tincture of aconite, equal parts) diluted with alcohol, according to König, fulfils the requirements "which are considered in all modern efforts at disinfection as most essential, *i. e.*, hardening the skin, tanning it, as it were, and fixing the bacteria for some time in such a way that they cannot get into the wound. That iodin, besides these properties, retards bacterial growth is a well-known fact." Iodin clings for a long time to the tissue to which it has been applied, thus insuring deep penetration. In a dilution of 1 to 6000, iodin still impedes bacterial growth. Lewy justly emphasizes that the tanning of the mucosa is an advantage "facilitating, as it does, the introduction of the needle into spongy gums." The purely superficial brown coloration of the place of injection is also of importance, as it very clearly marks the prepared portion of the skin to be injected. The objections that have been raised against iodin as a disinfectant of the mucous membrane cannot be maintained unless an idiosyncrasy for iodin be present. The author has never noticed any lesion or sloughing in the area of injection following the application of weak iodin. It will not occur if the iodin solution is fresh.

The painting with iodin is accomplished by not merely applying a few touches, but by repeatedly wiping to and fro, in order to combine real mechanical cleansing with the disinfection, and to effect penetration.

Ten per cent. thymol alcohol has also been successfully employed for disinfecting the point of insertion of the needle. The lack of the characteristic brown discoloration following the application of tincture of iodin, however, seems to be a drawback. Mueller-Widmann recommends a chloroform solution of iodin (iodin 1 part, chloroform 15 parts), to render the insertion of the needle less painful. Riethmuller an iodin-menthol-benzol mixture (iodin crystals 10 parts, menthol

crystals 10 parts, benzenum U. S. P. 80 parts) for the same reason. This stable solution will not produce the sloughing following the application of ordinary tincture of iodine which must be not older than one week, else it will decompose into hydriodic acid, while benzol will preserve iodine indefinitely. This iodine-menthol-benzol mixture is also a valuable indicator as to whether a patient is suitable for conduction anesthesia. Nervous patients and children who object and utter complaints upon application of this solution, which has a slightly smarting then cooling effect, are best subjected to a general anesthetic.

### PREPARATION OF THE PATIENT.

One feature in local anesthesia which has received altogether too scant consideration by the dentist, is preoperative medication. "The preparation of the patient by narcotics, such as morphine, scopolamine, veronal, etc., has proved most useful in local anesthesia. Most patients do not require such preparation which is contraindicated in minor interventions. It becomes a necessity, however, in timid and nervous patients, and generally in operations which by their nature and duration impose considerable demands upon the patient's courage and endurance. Scopolamine-morphine hypodermatically is excellent for such preparation except that the dosage of scopolamine is difficult; the customary dosage of 0.005 gram of scopolamine and 0.01 gram of morphine often proves inadequate and no more efficacious than pure morphine, while in the old and feeble it may be excessive." (Braun).

In case dental patients exhibit great excitement and fear, camphorated validol (from 7 to 100 drops in a little water); or chloralhydrate (from 2 to 3 capsules); or morphine 0.02 gram and hyoscin 0.005 gram in aqua destillata 10 c.c., from 6 to 8 drops in a tablespoonful of water, are given internally from thirty to forty-five minutes previous to operation; or chloral hydrate, from 0.5 to 1 gram.

Bromural (0.3 gram) administered internally, one tablet for children, two tablets for adults, to be taken forty-five minutes before operation, has given great satisfaction. It is important that these hypnotics be given sufficient time to act before the patient enters the operating room.

## PART II.

### INDICATIONS FOR LOCAL ANESTHESIA.

#### DANGERS OF LOCAL ANESTHESIA.

THE dangers of local anesthesia vary according to the method employed and the care observed in introducing the anesthetic. With cocain substitutes these dangers are considerably less than with cocain itself. Whole volumes could be written about the syndrome of untoward symptoms which cocain may produce in the organism. "Cocain is contraindicated in persons with diseased or weak heart, while novocain seems harmless, and, so far as we know, can be applied with impunity even during pregnancy and lactation." (Williger.)

Least dangerous is local anesthesia with ethyl chlorid, which may be used to advantage for producing insensibility in pericemental diseases of the anterior teeth. Many practitioners apply the ether spray, especially in children, for the production of a brief analgesia. Only small quantities, however, should be employed, as this anesthetic is by no means harmless in children, and even small doses of it may produce syncope or sudden death. It should never be employed near an open flame or in connection with a thermocautery, owing to the danger of fire.

In obstinate and unmanageable children, and sometimes in intractable adults, the induction of a brief analgesia is preferable to local injection. These are practically the only cases in which nitrous oxid and oxygen analgesia, at present so popular among American dental practitioners, can compete with novocain-suprarenin anesthesia, and even these exceptions prove the rule of the vast superiority of local injection, as any one familiar with both methods will attest. Ether

analgesia, according to Braun, is a fairly safe form of narcosis suitable for short interventions such as simple extractions. The inhalation of a few whiffs of ethyl chlorid produces a brief condition resembling alcoholic intoxication, which has led to the erroneous belief that it is the freezing of the gingivæ which renders the extraction painless.

Analgesia alone can be considered in dental operations in competition with local anesthesia, while full anesthesia should be a thing of the past for the dentist. At any rate, it is so rarely called for in dental practice that he need not or cannot acquire sufficient practice in it, but, if demanded, should engage an expert anesthetist. Analgesia involves the disadvantage that it is not always satisfactory, inasmuch as its duration and depth are insufficient if the least complication arises in extractions, and sometimes excitement and frequently erotic or unpleasant dreams occur in patients. For these reasons the presence of a third person is imperative. Local anesthesia, on the other hand, offers a simpler and safer method of an infinitely wider range of usefulness, which does not require the services of an assistant. In complicated operations which last more than a few seconds, local anesthesia alone is indicated, as any one will admit who has witnessed a resection of a mandible under general and one under local anesthesia. Local anesthesia is not only equivalent but far superior to general anesthesia.

The possible danger from hypodermically injected drugs must always be realized, first, because the toxic effects of these solutions may be variable; second, because an injection may be followed by untoward sequelæ. Every local anesthetic has a toxic action, and one should never forget that novocain also is a poison. The employment of excessive doses, also an idiosyncrasy on the part of the patient, may produce serious toxic symptoms. If, however, the operator has correctly judged the character of the surgical intervention, the resistive power of the patient, and the maximal dose, *i. e.*, the specific toxicity of his solution, he will have no accidents ordinarily, if he has observed strict asepsis.

Locally the NS solution recommended involves no risk of tissue lesions whatever. Even when employed in large quantities, this drug

has an indifferent action, and is very well tolerated by the tissues. Necrosis used to occur when cocain solutions of high percentage or proprietary preparations containing strongly escharotic drugs as carbolic, hydrochloric, or nitric acid were still in vogue.

**Breaking of the Needle.**—A possible local accident to be reckoned with is the breaking of the hypodermic needle, a fragment of which sometimes disappears so rapidly in the mucosa and loose connective tissue that it cannot be found again. These accidents have increased in number since the introduction of conductive anesthesia, and have occurred mostly in mandibular injection. In our opinion, very frequently lack of technical skill and unfamiliarity with the correct method of procedure are responsible for such accidents. Only new steel needles, or those that have been used but a few times, should be employed; rusty ones break easily. Iridio-platinum needles are far preferable for this, if for no other reason. Thin needles, of course, are more apt to break than stouter ones, and, since the break usually occurs at the mouth of the hub, long needles are safer. This risk, it is hoped, will be eliminated by the use of the trocar cannula previously described.

The needle may, however, break without the operator's fault, if, for instance, the patient moves his head or gives a sudden start. If the needle fragment has been sterile and free from rust, it seems to heal in without causing any trouble, as has been noted in several cases. It is quite possible, however, that complications may be produced by the fragment later on. In all such cases, therefore, an attempt should be made to remove it, after determining its location by a Röntgenogram.

If, in subperiosteal injection, the operator has properly palpated the tip of the advancing needle, he will, with some experience in minor oral surgery, be able to fix the fragment, and, after waiting for the completion of the anesthesia, locate it by a transverse, never a vertical, incision with a sharp, sterile lancet, and pick it out with sterile pliers. If this attempt is unsuccessful, or if a needle is broken during conductive anesthesia, a surgeon must be summoned to extricate the fragment.

Williger recommends the following mode of procedure in case of

breakage of a needle: "In order immediately to obtain reliable points of orientation, a long sharp sound is inserted in the direction in which

FIG. 13

*a**b*

*a*, needle broken at level of sigmoid notch; *b*, needle broken at customary level of insertion. (After Williger.)

the injection was made, and with this in place, a radiograph is taken. This picture will give valuable landmarks for the relative positions of the sound and the needle fragment. As it is uncertain at what distance mesially of the ascending ramus the needle is situated, the mucosa is freely incised parallel to the ascending ramus. This is done under infiltration anesthesia with 1 per cent. novocain solution with liberal suprarenin admixture (3 drops to 2 c.c.) To facilitate keeping the mouth open, a rubber gag is inserted between the teeth on the opposite side. The needle can then be easily located and removed."

**Idiosyncrasy.**—Without any fault of the operator, intoxications are sometimes caused by idiosyncrasies, indisposition, and reduced power of resistance on the part of the patient. It is hardly possible to know or diagnosticate, in advance, the patient's disposition to abnormal reaction to certain drugs. Some persons do not tolerate cocain and exhibit grave toxic symptoms even after the minutest dose. Others, again, are indifferent to large doses, which fail to produce in them the desired anesthesia. Still others who do not tolerate alypin, for instance, react perfectly normally to other salts, such as novocain, and *vice versa*.

Very frequently, by way of anamnesis, the details of such peculiarities may be learned or information obtained from the patient himself.

At all events, caution is required with patients who complain of palpitation almost immediately after the introduction of the needle, or show a disquieting change of the color of the face. In doubtful cases small quantities and weak doses of the anesthetic should be employed at the start. A slight acceleration of the pulse is notable after every injection, but usually the pulse rate soon returns to normal.

**Novocain Dermatitis in Dentists.**—The occasional occurrence of dermatitis in dentists has received considerable attention in the recent dental literature of America. This idiosyncrasy to novocain, which is possibly acquired through handling it, exhibits the following symptoms, as described by C. G. Lane<sup>1</sup>. This dermatitis begins on the

<sup>1</sup> The Dental Cosmos, September, 1921, p. 878.

hands, and perhaps between the fingers, with a slight redness and an itching or burning. These symptoms gradually increase in severity, the area spreads, there may be the appearance of tiny blisters or vesicles, which increase in size, and finally break down, perhaps of themselves and perhaps because of the scratching. The itching and burning are often very marked and may produce much discomfort. It may be that the whole hands are affected, though the dorsal surface, which is more tender because it is not covered with the thick palmar skin, is more likely to show the more severe type of irritation. Serum exudes from the vesicles, dries, forms crusts, and continued scratching and irritation results in the formation of fissures, possibly areas oozing blood, with heavier crusts and deeper fissures, particularly at the points of greatest flexion. The nails may be discolored and fissured, and there may be much redness and irritation about the nails." Additional and most distressing symptoms have been reported as affecting the face and the eyes; their origin is evidently due to contact with drops or spray of novocain solution when ejecting air bubbles from the syringe previous to injection.

The methods of treatment suggested, aside from preventing any more of the drug from reaching the skin or eyes, are: dipping the hands frequently into hot water, and wearing rubber gloves which must be carefully washed inside and out, dried and powdered after each use. For local application, the following remedies are indicated: salicylic acid and alcohol (20 gr. per ounce), a coating of vaseline to be applied nightly; a paste of sulphur and vaseline; an ointment of salicylic acid, 10 per cent. and benzoic acid 4 per cent.; bismuth and corn starch in equal parts; breaking up of the little vesicles by brushing with a stiff brush charged with green soap and hot water, afterward sponging with pure grain alcohol and mild Dakin solution alternately to hasten healing.

The occurrence of this irritation, which fortunately is comparatively very rare, again emphasizes the necessity of greatest care in handling novocain solutions and syringes.

**Shock and Collapse.**—Shock is of great importance in anesthesia. The psychic shock is invariably greater in local than in general anesthesia, the patients being under the impression that they are to undergo

an operation while fully conscious. In hysterical and highly nervous patients difficulties may be encountered in persuading them to submit to local anesthesia, owing to their reduced resistance to psychic shock. Pronounced hysteria, therefore, is a contraindication to local anesthesia. Cases have been reported in which the patients collapsed before the injection or suffered severe shock before any anesthetic whatever had been applied.

In nervous patients of low vital resistance and in persons without self-restraint or courage, special persuasion is required to dissipate all fear before the operation. In such cases success will be assured only to that operator who, by his skill, training, and familiarity with the method of procedure is capable of fully keeping his promise. It is a great mistake for any operator to guarantee full success before the operation, because, in case of failure, he undermines his reputation thereby. Besides being most unprofessional and unscientific, such a guarantee is apt to arouse more suspicion than confidence in an intelligent patient.

**Antidotes in Collapse.**—A number of effective measures may be adopted in case of disquieting symptoms. In light affections, such as palpitation, rapid pulse, pallor, perspiration, and trembling, a decoction of strong black coffee, fresh aromatic spirits of ammonia, or from 5 to 7 drops of camphorated validol in a little water are administered internally; in more serious affections amyl nitrite, from 1 to 3 drops on a napkin, ether in small quantity or oxygen is given by inhalation.

*Validol* is a colorless liquid of mild, agreeable odor and refreshing taste. It consists of menthylester of valerianic acid with 30 per cent. of free menthol and 10 per cent. of camphor. It is insoluble in water, but readily soluble in alcohol, and, if given internally, in doses of from 5 to 7 drops in a tablespoonful of water, constitutes an ideal restorative in serious cases of collapse.

*Amyl nitrite* is a clear, volatile, yellow fluid with fruit-like odor. On inhaling the vapor, flushing of the face occurs, the pulse is accelerated, and vascular dilatation in the head and thoracic region is produced. The increased blood-supply to the head and brain counteracts the anemic condition present, and prevents collapse.

Disquieting symptoms of a lighter nature following injection, fainting, or syncope may be combated by placing the head in a recumbent position. In serious cases the heart must be stimulated; the chest is wrapped in wet cloths, and cold douches, coffee or a hypodermic injection of oil of camphor, adrenalin, or quinin, strychnin and nitro-glycerin are administered. A few or all of these agents should be kept ready for use, as immediate application is essential.

Injections may produce two further unpleasant sequelæ, namely, postoperative pain and hemorrhage.

**Postoperative Pain.**—Postoperative pain is often due to purely accidental conditions of the wound, *i. e.*, sharp splinters of bone remaining in an empty alveolus, sloughing of the margins of the wound, insufficient hemorrhage and clot formation after excessive ischemia, injection of non-isotonic solutions or those containing strongly toxic agents, insufficient disinfection of the field of operation, infection from extraction with unclean instruments, or the patient's touching the wound with septic fingers, also from food debris, all of which can be averted by suitable precautions.

While it is irrefutable that every anesthetized wound will pass into a state of more or less pronounced hyperesthesia, from which it returns to a normal condition sooner or later, yet from personal experience, it is safe to assert that, if the anesthetic solution has been made with Ringer base, and the injection correctly performed, no postoperative pain is to be expected. If all the necessary precautionary measures have been observed, even severe inflammations of the periosteum subside in due course of time, after the effect of the anesthetic has worn off. "The claim that postoperative pain is more severe in patients operated upon under local anesthesia than in those operated upon under general anesthesia," Braun writes, "is contrary to all our experiences. There are, of course, patients who for various reasons suffer severe pain following operations, regardless of what method of anesthesia might be employed. Local anesthesia, however, does not intensify such pain, but rather reduces its duration until the return of full sensibility."

Postoperative pain is attributable to various causes, rarely of

internal nature. Sickly persons of low vital resistance, convalescents, pregnant women, etc., seem inclined to edema and pain in the operative field, even when perfect technique has been employed in the injection. But there are some normal patients who invariably react to an injection by swelling and after-pain. These cases, however, are in a very small minority as compared with the instances of after-pain which are due to faulty solution, infected instruments and operative field, post-operative infection of the wound, gaping wound edges, shattering of the alveolar process, sharp bone edges. In all such cases the operator can hardly be exonerated of contributory negligence; he is indubitably guilty, if he employs secret preparations which often cause serious inflammation and suppuration, or if his ignorance of the necessary precautionary measures and of the proper technique of injection produces a septicemia with possibly fatal result. Postoperative pain and edema are frequently due to infected solutions. The operator of aseptic habits will never observe any untoward sequelæ.

The greatest mistakes are made in regard to asepsis, for there are still many operators who make an injection without having previously disinfected the mucosa. By simply swabbing with iodine, as described above, or 5 per cent. mercurochrome solution, the great danger of infection, frequently followed by edema, is materially reduced.

A. Cohn, of Berlin, reports a case which is interesting in this connection: "A patient, aged twenty-seven years, asked me to extract an upper third molar affected with pericementitis. The injection and extraction were entirely successful. About four hours afterward, postoperative hemorrhage occurred, with a sensation of heaviness in the left limb. The hemorrhage was readily arrested. The following day grave symptoms of blood-poisoning occurred, combined with paralysis of the left arm and leg, which led me to suspect intoxication by novocain-suprarenin. This diagnosis had to be abandoned, however, when on the following day the right side also became paralyzed. It was then ascertained that, despite careful injection, streptococci had caused embolism in the lumbar region, producing paralysis of the legs, which has not yet disappeared (two years after), while the

other symptoms vanished. This accident, therefore, must be regarded as indirectly due to local anesthesia."

In many cases, postoperative pain after injection is of psychic origin, as Cieszynski has pointed out. His assertion, however, that after-pain most frequently follows pulp extirpation under anesthesia is untenable.

After thoroughly cleansing the wound and removal of bone fragments or decomposed blood clot postoperative pain is prevented or counteracted therapeutically by internal administration of morphin, trigemin (0.25 gram per dose), aspirin (1 to 3 tablets), pyramidon (0.3 gram per dose), or combined doses of pyramidon (0.1 gram) and aspirin (0.3 gram), or of any two of these drugs followed by a glass of hot milk. Cold compresses also have proved most useful. In wounds, especially inflamed ones, tamponing with pure novocain powder renders surprisingly good service. The cavity of the wound is carefully cleansed and sterilized with hydrogen peroxid and a layer of about 2 mm. thickness of novocain powder (from 0.5 to 1 gram) is introduced, and a gauze tampon, of 10 per cent. iodoform gauze, which also has been previously charged with novocain powder, is applied with very light pressure. Instead of iodoform gauze, .vioform or 10 per cent. boric acid gauze may be used in order to avoid the disagreeable odor and taste of iodoform. For some time we have employed a convenient powder-spraying syringe, from which, by compressing a rubber bulb, pure novocain is blown through a hard rubber tube which is held close to the wound. This procedure of disinfecting and tamponing the wound is repeated every twenty-four hours, after which the healing process is left to itself without any further therapeutic aid. (See section on Anesthesia in the Therapy of Inflammation, page 120.)

To prevent after-pain following extractions, Gutbier employs enguform, a condensation product of guaiacol and formaldehyd, as a dusting powder.

In cases of severe inflammation with general depression due to pain from pulpitis or pericementitis, doses of morphin internally are most favorably indicated, especially if given half an hour before induc-

tion of anesthesia or extensive dental operations. The formula is as follows:

|                                                |       |
|------------------------------------------------|-------|
| Morphin . . . . .                              | 0.2   |
| Hyoscin . . . . .                              | 0.005 |
| Distilled water . . . . .                      | 10.0  |
| From 6 to 8 drops in a tablespoonful of water. |       |

Besides its pronounced sedative effect, this dose accelerates the wound healing and prevents untoward reaction. The extensive application of anesthesia in the therapy of inflammations is especially indicated in dentistry. With this point in view, the writer has compounded an arsenic paste which contains arsenous acid, novocain,  $\bar{a}\bar{a}$  4; thymol, iodoform,  $\bar{a}\bar{a}$  0.5; glycerin, chlorphenol crystals,  $\bar{a}\bar{a}$  enough to make a paste; to be incorporated in asbestos fiber. This paste has proved most efficacious in the practice of many operators.

**Postoperative Hemorrhage.**—Postoperative hemorrhage caused by injection is very rare indeed. It is arrested according to the principles recommended by Williger, the chief measure being tamponing. A normally bleeding wound, however, should never be dressed with tampons. Novocain tamponade is applied only superficially, so that the formation of granulating tissue or blood-clot in the fundus of the wound is not inhibited.

Injuries to bloodvessels are without serious significance; for as Braun says, it is immaterial whether an artery, even the internal maxillary or carotid, is punctured with a fine needle. In the worst case, a harmless small hematoma may result. An injury to a bloodvessel becomes dangerous only if the sterility of the solution or the instrumentarium has been neglected. Infected hematomata invariably lead to abscesses and may produce serious sequelæ as the swelling is usually quite extensive. The puncturing of bloodvessels can be safely avoided if the solution is ejected from the syringe in close proximity to the bone.

From 3000 experimental cases of injection, Kühns estimates that in about 1 per cent. of infraorbital, 2 per cent. posterior palatine foramen, 1 case each of maxillary tuberosity and anterior palatine foramen injections, and in 1 of 1000 mandibular injections bloodvessel injuries

occur. In these cases he observed characteristic zones of anemia of the face or the mucous membrane (see Fig. 14) which were of no serious

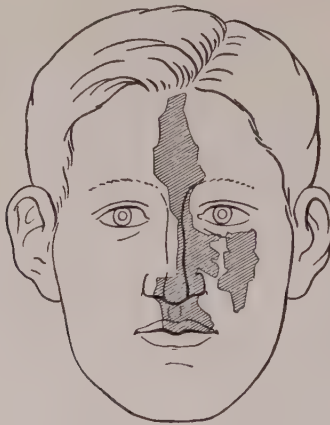
FIG. 14



*a*, zone of facial anemia, following injection at maxillary tuberosity.



*b*, after injection at infraorbital foramen.



*c*, after injection at incisive foramen.

Vascular lesions following local anesthesia. Zones of facial anemia. (After Kühns.)

consequences to the patients. He therefore considers the puncture of a bloodvessel to be non-injurious to the patient. Though these injuries

may not be entirely avoidable, they can be reduced to a minimum by following Reclus' rule of injecting while advancing the needle thereby forcing the bloodvessel aside and contracting it prior to its possible injury. The rapidity of injection also is of utmost importance. The more slowly and cautiously the needle is advanced, the more certainly will injuries to larger bloodvessels and sudden toxic symptoms be avoided.

Injuries to the lingual nerve have been discussed by H. Kron. The lingual nerve, owing to its superficial situation under the lingual mucosa, may be endangered by contusions during extraction of lower molars, also by local injections. In lean patients this nerve may be seen through the thin covering of mucous membrane. In one case the lingual nerve trunk together with fibers of the accompanying chorda tympani was severed by incision of a lingual abscess of a lower third molar, resulting in loss of sensation in the tongue on the injured side. As a consequence, the patient, female, lost her sense of orientation regarding the position of the tongue in the mouth resulting in loss of coördination of the otherwise sound lingual muscles. No improvement resulted from treatment with the galvanic current.

In another case, the patient, aged fifty years, experienced suddenly an intense pain lingually to the third molar, while being injected locally. Numbness on that side of the tongue rapidly ensued. The following day serious trismus supervened together with necrosis of the soft tissue extending to the region of the ascending ramus of the mandible. After nine months, the numbness on the left side of the tongue persisted, speech was seriously impeded, and the tongue had a tendency to slip between the posterior teeth, though taste was not impaired.

From these cases it appears imperative to refrain from injections at the lingual side of lower molars, especially to keep away from the floor of the mouth. The sensory lingual nerve is endangered even in extractions of third molars, as has been shown by Roser and Trauner. In a young lady the removal of both lower third molars was followed by neuralgia of the lingual nerve on both sides, which was attributed to contusions of the nerve within the socket.

Pricking of nerve tissue caused by sharp needles heal rapidly.

without any secondary sequelæ. Paresthesias, however, frequently follow the laceration of nerve trunks by dull or bent needle points.

Altogether the complications that may arise during or after local anesthesia are far less numerous and not so serious as those involved in general anesthesia; consequently, the prognosis in the latter is far more uncertain and unfavorable than in local anesthesia.

Secondary effects of this nature are fewer in direct ratio as the technique of conduction anesthesia is mastered. As the anesthetic solution is deposited at a distance from diseased area, it exerts no direct action thereupon. Subperiosteal injections are more prone to cause trouble, because the process of infiltration, the subsequent anemia, and the resulting irritation of the wound, may produce complications. After conduction anesthesia, on the other hand, the hemorrhage and the behavior of the tissues involved in the operation are the same as after general anesthesia.

### ACCIDENTS FOLLOWING NOVOCAIN INJECTIONS.

Serious intoxications after injection of novocain-suprarenin solution have never been observed by Fischer personally, unless we were to regard a case of narcotic slumber as one of dangerous intoxication. The case referred to was as follows:

**Narcotic Slumber Following Novocain Injection.**—Before extracting the gangrenous roots of a lower second molar in a strong and healthy woman, aged thirty-six years, local anesthesia of the mucosa was induced; 3 c.c. of a 2 per cent. novocain-thymol solution, as employed at that time, were injected, 3 drops of fresh synthetic 1 in 1000 suprarenin solution having been added immediately before injection. The injection, as in all patients of strong constitution, was completed without pain. The period of waiting for the establishment of perfect anesthesia, owing to the tardiness of diffusion in the mandible, was calculated at fifteen minutes; in the meantime two cavities in upper teeth on the same (left) side were to be excavated. Very soon (about one minute) after the injection, the patient noted considerable numbness in the entire left mandible, similar to that produced by conduction anes-

thesia, and five minutes afterward could no longer feel the touch of the rinsing glass on that side of the lip. The vascular system was affected at the same time by a slight acceleration in pulse, lasting for two or three minutes, whereupon the patient lapsed into a condition of semi-slumber or light sopor, and exhibited difficulty in keeping her mouth open. Pulse and respiration soon resumed their normal rate, and the patient seemed to be sleeping comfortably. As in hypnotic sleep, she answered every question, rinsed, opened, and closed her mouth as requested, in short, followed all directions, without, however, opening her eyes or being conscious of her actions. The two cavities, after painless excavation, despite close proximity to the pulp, were filled with amalgam inserted over a protective cement step. In the meantime twenty minutes had elapsed since the injection, and the two badly carious roots were extracted. Immediately afterward the patient suddenly straightened herself up with a start, opened her eyes and, according to directions, vigorously rinsed the mouth. From this moment she assumed an entirely changed attitude, acted perfectly normally, and stated that a pain as from pressure had startled her. She still felt the numbness in the left side of the mandible, and was almost ashamed when told of having been asleep. She boasted of always having enjoyed an exceptionally strong constitution, and, as if to excuse herself, mentioned that her system reacted with extraordinary readiness and intensity to any medicament. To this peculiarity she ascribed the slumber following the injection, saying that the normal dose evidently had affected her very strongly. She did not know what operations had been made in her mouth, and was glad to hear that her upper bicuspid had been filled in the meantime. She left in normal possession of her senses and feeling quite well, and experienced no further after-effects.

This case of brief "hypnotic" slumber was probably due exclusively to the action of the novocain and the unusual susceptibility of the patient. No erotic symptoms were noted in this case, such as are frequently observed in general anesthesia, also sometimes in local anesthesia with ethyl chlorid or cocain. Nevertheless, such symptoms may occur in sexually highly excitable individuals after novocain

injection, which again justifies the demand that not only during general but also during local anesthesia a third person should be present to avoid all risks of suspicion.

Since the patient's excellent state of health in the case cited was corroborated by her physician, the writer is inclined to consider the extraordinary effect of the novocain as a mild intoxication, causing an irritation of the central nervous system.

**Toxic Action of Novocain.**—It is remarkable that in the above case there appeared none of the heretofore observed phenomena of intoxication by novocain, which Liebl has endeavored to test in his own body. Upon injecting 0.75 gram of a warm 10 per cent. solution in his right thigh, this investigator noted, after four minutes, "a sudden, strange warmth in the entire body, especially in the region of the liver, slight malaise, symptoms of nausea, and general agitation, but no notable change in pulse or complexion. Two minutes later slight deafness in the left ear set in; also ocular disturbances; accommodation in both eyes, especially in the left, being possible only with great effort; and diplopia. Thirteen minutes after the injection slight pungent headache on the left side was noted; after seven additional minutes, paresthesia in the region supplied by the radial nerve on the left side." After about half an hour of general malaise normal ease returned.

The slight acceleration of pulse shortly after injection is perhaps to be attributed to the suprarenal extract rather than to the anesthetic, since it has not been observed when pure novocain solutions were employed. Liebl also emphasizes that in his own case no change in pulse and complexion was noted.

It is interesting and important to note that even novocain, although it is almost devoid of irritating action on the tissues, and can be tolerated even pure without disturbances, if applied topically and externally, may occasionally produce irritation of the central nervous system, even in a dosage far below the maximal. On the other hand, it must not be overlooked that an organism which reacts even to the lightest chemical stimuli will tolerate a maximal dose of novocain alone far below the average. To cite Braun: "Whether

and in what intensity novocain intoxication occurs in the central nervous system by no means depends only upon the dose of novocain introduced into the blood, but also upon the time allowed for its introduction. If introduced into the blood suddenly, or in concentrated solution—in the reported case the injected solution exceeded in its action that of the usual maximum dose—immediate toxic action may result from a dose which, if administered gradually, *i. e.*, in dilute solution, or in portions at intervals, may not produce even the slightest suggestion of an intoxication of the central nervous system, because then the concentration of the novocain in the capillaries of this organ will at no time exceed the toxic dose.”

Klein also claims to have observed pronounced symptoms of intoxication from novocain in five cases, three of which he attributes to complication with functional disorders of the heart, lack of resistance of the whole organism, and abnormal menstruation. In his other two cases, however, he regards novocain as exclusively responsible for serious symptoms of collapse. Just as the case reported by Fischer seems to illustrate an instance of extraordinary action of novocain solution that must be judged by itself, so the two cases of intoxication reported by Klein, which apparently cannot be ascribed to any other causes, must be regarded as abnormal exceptions to the rule. From our own experience with the use of novocain, extending over a period of many years, we can only once more emphasize its eminent advantages over cocain, even though novocain, as we have seen, may occasionally produce untoward secondary effects. Until now these cases have been of such a mild or trivial nature, and so far above comparison with cocain cases, that novocain loses none of its great superiority in regard to the relatively almost complete absence of irritation. A local anesthetic, as Liebl has definitely established, “surely possesses extremely favorable properties, if, like novocain, it only occasionally produces relatively harmless symptoms of slight intoxication, which cannot be compared for one minute with the ghastly clinical picture of cocain intoxication, and does it only under conditions specially favorable for the appearance of symptoms of absorption, that is, at body heat, and only in the high dose of 0.75 gram of a 10 per cent. solution, which is never employed in local anesthesia.”

Cases of gangrene and necrosis following novocain-suprarenin injections, which have now and then been reported, have in every case been traced to stale and infected solution, lack of sterility of the instrumentarium, and injudicious injection directly into a focus of infection. This last cause is also responsible for the "case of novocain peridental anesthesia followed by unpleasant symptoms," as reported by John S. Marshall,<sup>1</sup> in which 0.09 gram of a novocain-suprarenin solution had been injected peridentally for the extraction of two molar teeth affected with pyorrhea alveolaris. Granted that every step in the operation was performed under strictly aseptic conditions, granted even that the solution which was prepared from novocain-adrenalin-sodium-chlorid tablets which have proved unstable, was perfect, the symptoms of malaise, constriction in the region of the heart, labored breathing, and increase in pulse rate which were noted on the day following the operation are clearly those of mild septicemia due to the bacteria and toxins carried from the pyorrheal area into the blood by the needle and the injected fluid, but not, as Marshall suspects, manifestations of the cumulative effect of novocain.

Statements regarding accidents due to the toxicity of novocain, especially those appearing in the lay press, should invariably be accepted with a grain of salt, inasmuch as the case histories given are rarely complete and intelligible enough to enable the expert to draw his own conclusions as to the real cause or causes. Such reports usually contain statements and inferences prejudicial to novocain, which should be carefully verified before acceptance. As the *British Journal of Dental Science*<sup>2</sup> aptly remarks, editorially: "The dental and medical world have for a considerable time regarded novocain as an ideal local anesthetic, because, if injected with proper aseptic precautions, it involves, so far as we know at present, no risk whatever to the patient. An anonymous correspondent to our contemporary (*The Times*) complains of an immediate effect upon the heart, 'a tingling sensation of the nerves near the region of the heart,' followed after an hour by 'a bad heart attack,' accompanied by a sense of

<sup>1</sup> Items of Interest, March, 1914, p. 220.

<sup>2</sup> March 16, 1914.

suffocation and intense pain, and during the subsequent two months several similar attacks, ending in a nervous breakdown. Before these experiences can be of any service in extending our knowledge of the effects of novocain, many things will be necessary. We shall require to know all about the general anesthetic that was administered just before the novocain was injected, what was the exact nature of the preparation employed, its strength, and whether it was freshly prepared; whether any of the ritual of asepsis was omitted, and, most important of all, we must know from some reliable medical authority the condition of the patient's cardiovascular system. No doubt the 'Reader of *The Times*' was quite unaware of the fact that no single injection of novocain ever has or ever could produce consequences lasting two months. Septic poisoning might possibly have a lingering sequel, though recurrent heart attacks could scarcely constitute the symptoms even in such a case. Some of the writer's expressions would be explained by an attack of angina, but from a perusal of the letter and without further information we should unhesitatingly refuse to believe that an injection of novocain had anything whatever to do with the sequelæ." After citing similar reports, the *Journal* continues: "The interest of these letters is chiefly this: that while they attribute amazing consequences to an injection of novocain, and can hardly be expected to lead to any really useful result, they may cause widespread mischief to the community by raising a groundless panic with reference to the use of a very valuable and, when properly employed, a very safe local anesthetic. If such loose appreciations of the nature of cause and effect are allowed to disturb the public mind, then every sufferer from gastric trouble and consequent cardiac symptoms traceable to another cause will be able to find an explanation of months of trouble in one injection of novocain, and possibly this may prove a more convenient explanation for circulation in the family circle." To this we might add that it is extremely unfair to the patient and to the science of local anesthesia if a dental practitioner, as occurs occasionally, attempts to cover up his own omissions and commissions in an untoward case by laying the blame on the "toxicity of the drug."

Personally, we have not experienced a single instance of serious intoxication following injection. The few interesting observations of abnormal action of novocain merely corroborate the old postulate of individual discrimination in the administration of every drug.

**Hysterical Spasms Following Novocain Injections.**—Several cases of hysterical spasms following novocain injection have been reported, one by Kehr,<sup>1</sup> one by Knoche, of Gotha, and one by Jelonek, of Duisburg. In all these cases the patients were subject to hysteria, which broke out under the added stimulus of the novocain injections. In the last case reported, the patient had tolerated novocain very well on former occasions, which proves that the novocain produced no specifically toxic effect, but was merely the final contributing factor to a long-due new outbreak of hysteria, the predisposition to which was greatly enhanced at the time of the last injection, while during previous injections the disease had lain dormant. All the details of this last case confirm our opinion of the infinitesimal danger of intoxication from novocain, which has been found to be and for the present remains the best and least toxic anesthetic. Its relative toxicity, to quote Braun once more, "is incomparably smaller than that of all heretofore known local anesthetics; for the extraction of teeth, therefore, this drug is most favorably indicated."

These case reports corroborate what has already been demonstrated, namely, that even entirely harmless doses of novocain occasionally may act toxically by eliciting an outbreak of already established nervous diseases, especially of hysteria. These outbreaks, however, would have been induced by any other nerve irritation. The procedure of injection and operation in itself is an unusual experience which, for a highly excitable patient, it is difficult or impossible to overcome. In hysteria, therefore, as has been said before, special precaution is required on the part of the operator.

**Unduly Prolonged Duration of Local Anesthesia.**—Several cases of anesthesia lasting for weeks or months and extending over smaller or larger areas have been reported, and again it was possible to prove that these most disagreeable after-effects were not due to any toxicity

<sup>1</sup> Deutsche Monatsschrift für Zahnheilkunde, January, 1910.

of the novocain-suprarenin solution, but to surgical injury of a nerve trunk inflicted accidentally, especially during the extraction of teeth with abnormal roots. The therapeutic measures in these cases consisted in electric treatment and massage of the muscles of mastication, with the object of stimulating the regeneration of the injured nerve.

One case of brief temporary paralysis of the facial nerve also has been reported. In a review of these unusual dental cases, Braun writes: "Our surgical literature contains no reports of novocain intoxications, although we are daily using infinitely greater quantities than have been used in the cases in question; to mention only a few examples of operations which for years have been performed by many surgeons under novocain anesthesia exclusively: In hemorrhoid operations we regularly inject 100 c.c. of a 0.5 per cent. solution, in hernia operations from 100 to 150 c.c., in excisions of goitre from 100 to 150 c.c., in resections of the maxilla from 10 to 20 c.c. of a 1 per cent., and 75 c.c. of a 0.5 per cent. solution. Quantities of from 150 to 200 c.c. of a 0.5 per cent. solution, I have injected in hundreds of patients of every constitutional variety imaginable. Hesse, of Stettin, uses up to 250 c.c., Borchardt and Axhausen 150 c.c., the Heidelberg Surgical Clinic 50 c.c. of a 1 per cent. solution, each c.c. of solution containing 0.00012 gram suprarenin. Neither myself nor other surgeons have noted any after-effects except occasionally an attack of vomiting after injection of very large doses.

"It was only recently that I observed novocain intoxications in experiments with sacral anesthesia, in which 25 c.c. of a 2 per cent. novocain solution with suprarenin admixture were injected into the sacral canal. In some of these cases secondary effects were noted very soon after the injection, consisting in collapse, vomiting, and other disturbances which passed off within an hour. Owing to these experiences, I have discontinued these experiments. These observations, however, as well as those made in spinal anesthesia are not applicable to local anesthesia, because the anesthetic is applied in an entirely different way. It is unreasonable to think that novocain when injected into the gingivæ should act differently than when intro-

duced into soft tissue in any other part of the body. The peculiar phenomena which some dentists have observed here and there after injections of very small doses cannot be attributed to novocain.

"The case of unduly prolonged anesthesia mentioned can in my opinion be explained only as being due to hysteria. Pharmacologists have proved the innocuousness of novocain to nerve tissue in contradistinction to cocain, stovain, etc., therefore, whenever possible, we inject directly into nerve trunks."

It might also be suggested that the case of unduly prolonged anesthesia, as cited, might be due to alcohol having been left in the syringe and injected together with the anesthetic solution.

"At any rate," Braun concludes "all such observations teach us that even the smallest operative interference, no matter how carefully we proceed, may lead to dangerous complications which in all probability are due not to one single cause, but to an unfortunate combination of sometimes inexplicable conditions."

### SPECIAL INDICATIONS FOR LOCAL ANESTHESIA.

The question as to when local anesthesia is indicated cannot be solved within the limitations of this book, as our choice depends more or less upon the conditions presented in each case. For the dentist local anesthesia offers a wide field of application, and in its present state of perfection furnishes an invaluable addition to his resources. As long as major surgery is rapidly adopting local anesthesia more and more generally, dentistry, as a branch of minor surgery, should surely employ this method universally.

**Oral Surgery.**—In oral surgery, local injection can be employed in an infinite number of operations which it is needless to discuss here in detail. Besides extractions, all incisions in the mucosa, resections of roots, bone chiselling, cyst operations, partial resections, extirpation of small tumors, setting of fractures, etc., come under this heading. In all such surgical operations, before inducing anesthesia, the patient's head is protected with the head wrap indicated

by J. Witzel. A sterile napkin is laid over the hair and fixed with a safety-pin (see Fig. 15).

FIG. 15



Head wrap, designed by J. Witzel.

**Anesthesia of Pulp and Dentin.**—Several writers have recommended the method of injection for anesthesia of the pulp or the dentin. Its application in the conservative treatment of teeth is, indeed, most opportune. The principles governing the technique of anesthesia are the same in conservative interventions as in the surgical measures enumerated.

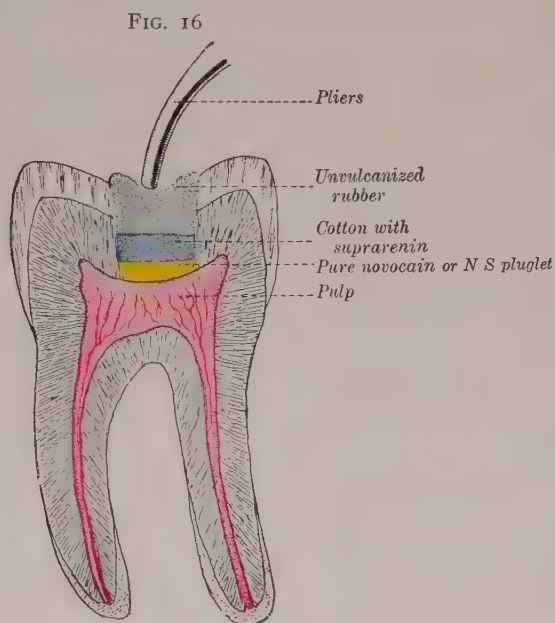
**Pressure Anesthesia.**—Although pressure anesthesia of the pulp is no longer regarded with favor by a large number of practitioners, we must briefly mention a number of measures which have been suggested for the direct anesthetization of the pulp and the dentin, without injection. Among other things, novocain-suprarenin pluglets and alypin pluglets are offered in the market for this purpose, which in

hypersensitive dentin often yield very satisfactory results. One of these pluglets is either rubbed with a round-headed instrument into the area of hypersensitive dentin, or introduced into the moist cavity, pressure being exerted with a suitably shaped instrument for from five to ten minutes. In cases of close proximity or exposure of the pulp, full anesthesia can sometimes be obtained by several applications. For desensitizing hypersensitive dentin in the preparation of a cavity, however, this method of direct anesthesia is extremely uncertain, and the operator is often obliged to resort to injection which in the great majority of cases affords absolute painlessness.

The anesthesia for the purpose of conservative treatment in many cases must be more profound than that for surgical purposes. It has, for instance, been observed that under mandibular anesthesia the extraction of a tooth was absolutely painless, yet the sensitivity of the pulp of an approximating tooth on the anesthetized side was not entirely abolished. In all dentinal anesthetics, therefore, either the usual amount of the anesthetic solution is increased by one-third, or the concentration of the solution is raised by using 3 instead of 2 tablets for the same amount of solvent, thereby insuring an almost certain effect. For the sake of completeness, we shall briefly describe a method which seems most suitable for pressure anesthesia, and with which every dental practitioner is familiar. Griffin<sup>1</sup> prefers for pressure anesthesia hypodermic tablets containing cocain, morphin, and atropin. One-third or one-half tablet is introduced in the cavity on a minute cotton pellet saturated with adrenalin, and allowed to lie on the exposed pulp for a few seconds. Then a piece of unvulcanized rubber slightly smaller than the cavity is laid over this pellet, and gentle pressure is exerted (see Fig. 16). If the patient shows the least sign of pain, the pressure is relinquished, to be again gradually increased, without, however, causing any pain. In approximal cavities the rubber is first firmly pressed against the cavity margins, and then slightly against the pulp. Small round-headed instruments are not suitable for this purpose, as they pierce the rubber and do not permit of uniform pressure. Only flat, broad pluggers should be used, as they can easily be lifted without

<sup>1</sup> *Ergebnisse der Gesamte Zahnheilkunde*, 1910, vol. iii.

displacing the rubber. After from one to three minutes, when the pressure is no longer painful, rubber and cotton pellet are removed, the opening into the pulp chamber is enlarged, and the pulp can then be immediately extirpated without pain or hemorrhage. A repetition of this pressure anesthesia within the pulp chamber is rarely necessary. This method is most convenient in exposed pulps, though it is efficacious even when the pulp is still covered with a thin layer of dentin.



Pressure anesthesia in exposure of the pulp.

For pressure anesthesia small rods or pluglets containing 0.01 gm. novocain and 0.0002 gm. suprarenin are in the market. These rods are applied in the same way as the cocain rods sold for this purpose. The anemia produced by the suprarenin allows of a cleaner operation with less danger of subsequent discoloration of the tooth, and is specially appreciated in children's teeth with large apical foramina. These rods produce perfect results even in advanced stages of pulpitis and in cases of pulp-stones, in which the familiar procedure may have to be repeated once or twice. The great advantage of these novocain-suprarenin

rods over cocain or arsenous oxid lies in the absence of pericementitis following pulp extirpation.

For confining the anesthetic in the cavity and distributing the pressure evenly, the use of weighted rubber is recommended, which is far superior to ordinary unvulcanized rubber. Cocain involves some risk, even when used for pressure anesthesia, in patients with an idiosyncrasy, as is illustrated by the following clinical case: A student in our Dental Infirmary, while attempting pressure anesthesia in the lower left second bicuspid of a young, healthy-looking woman, accidentally dropped a very small crystal of cocain on the patient's tongue, but immediately picked it up with cotton pliers, and requested the patient to rinse to remove the bitter taste of which she was complaining. After rinsing, the patient's extremities began to tremble, her pupils were dilated, breathing became labored, and in less than two minutes the typical syndrome of symptoms of cocain intoxication was noted. Restorative measures were at once applied, as the patient threatened to collapse. Not until one full hour afterward was she able to leave the Infirmary, accompanied by an assistant, owing to her weakened condition. Upon her return to the Infirmary several days afterward, she gave a history of hysteria, and stated that malaise had persisted for several hours. In this case of extreme susceptibility, the application of cocain to the pulp would in all probability have produced similar symptoms. The pulp was subsequently extirpated after devitalization by arsenous oxid.

Since none of the obtundents when introduced into a hypersensitive cavity or applied to hypersensitive dentin acts with sufficient certainty and without danger to the vitality of the pulp, we have conducted experiments to ascertain the applicability of anesthesia by injection for this purpose. These experiments with novocain-suprarenin solution have yielded such splendid results in regard to efficiency and innocuity that the injection method must be regarded as being the best at present for dentinal anesthesia. If, before making an injection, the condition of the pulp has been accurately tested by thermal, mechanical or electric stimulation, we can carry out our measures without harming the metabolism of the pulp, and can often fill such teeth at the same

sitting. After the anesthesia has worn off, the pulp will exhibit a hypersensitivity, but will soon return to normal. According to Euler's and Scheff's experiments, the life of the pulp is not imperilled, provided all due precautions in regard to solution, technique, and instrumentarium have been observed.

Injection of novocain-suprarenin produces also anemia, which is evinced by the pale appearance of the pulp tissue. Extreme care is therefore required in the preparation of a cavity, in order to avoid the danger of inserting a filling too closely to or directly upon an exposed pulp without protecting it by an aseptic pulp capping, or of overlooking the initial stages of an already established pulpitis. Such mistakes are apt to occur because all the usual criteria regarding the proximity or the condition of a pulp are obliterated by the anesthesia. Death of the pulp is the inevitable consequence of such errors in treatment. Cocain-adrenalin mixtures such as were at one time employed for the purpose of dentinal anesthesia often caused keen disappointment, because pulps anesthetized with these agents preliminary to cavity preparation would subsequently succumb to atrophy or necrosis. These failures were justly attributed in part to the adrenalin, the dosage of which was gradually reduced. Pure cocain, which is still unnecessarily used for obtunding hypersensitive dentin, possesses ischemic properties which are so intensified by the addition of an excessive quantity of an adrenalin preparation that the anemia of the injected tissue persists for a dangerously long period of time. Unless a pulp is exceptionally strongly constituted, it is incapable of recovery, and doomed to mortification.

**Quinin as a Sedative in Cavity Preparation.**—In highly sensitive, hysterical, or neurasthenic patients, in whom anesthesia is contra-indicated, it is of advantage before dental operations to give internal doses of quinin sulphate, 0.5 gram, or chloral hydrate, 1 gram, to quiet the nervous system. Le Monnier, of Nizza, who is said to have been the first to apply quinin in dentistry, reports as follows:

"In February and March of 1887, when the severe earthquake took place in Nizza, I had occasion to observe that many of my patients showed such nervousness that it was impossible even to touch

their teeth, and all the measures usually resorted to in such cases failed. Especially teeth in the advanced stages of caries were so sensitive that they could not be excavated, even after the application of caustics. One of my patients was seized with general neuralgia of the head, so that he excused himself for not keeping his appointment. Several hours later he appeared, however, and was treated. I noticed that he did not make the usual twitching motions, and learned that he had taken a large dose of quinin for his neuralgia.

"It then occurred to me to prescribe for another similarly nervous patient 0.5 gram of quinin sulphate, to be taken for two successive days. The same effect as in the former case was observed, and the patient's teeth could be filled during the next sitting. The quinin seemed to reduce the sensitivity of the teeth much more effectively than locally applied caustics.

"In the same year I had occasion to treat a woman who exhibited the same symptoms, and again I prescribed 0.5 gram of quinin for two successive days. I was agreeably surprised to see the patient return the following morning and submit to the required operation. These experiences have recently been corroborated, and I believe to have found in quinin sulphate a valuable addition to our medicinal resources in nervous cases."

**Chloral Hydrate as a Sedative.**—Chloral hydrate (from 0.5 to 1 gram) also is a sedative which obtunds the brain function and reduces the sensitivity of the teeth. In speaking of this drug, Seitz says: "In 1899 a young woman, aged eighteen years, who was undergoing nerve treatment in a sanatorium, presented for dental treatment. The year previous she had met with an accident while telephoning during a thunderstorm. Lightning struck the wire, and she fell senseless beside the instrument. When she regained consciousness, several hours afterward, hyperesthesia of the entire surface of the body had set in, intolerable pain being caused upon the slightest touch. In a year's time this hyperesthesia had somewhat abated after treatments of various sorts, yet it persisted in the trigeminal region, so that the mere touching of the teeth with a finger still caused great pain, and for the time being dental treatment could not be instituted. When,

however, idiopathic odontalgia set in, every possible therapeutic means had to be tried to give relief, and, since local application of chloral hydrate was unfeasible, the internal administration of this sedative was resorted to. The patient was given one powder of 1.5 grams in wine in the evening, and the same dose on the following day, half an hour before the operation. The sensitivity of the teeth was actually reduced to such a degree that even the dental engine could be used. During the operation the patient was in a semianarcotic condition and completely indifferent, and showed not the least sign of pain. Half an hour later she was able to return to the sanatorium by carriage. No secondary symptoms occurred.

"Similar cases have been reported in the July, 1900, issue of *Dental Office and Laboratory*. According to this report chloral hydrate was administered in doses of from 10 to 15 grains, which acted promptly even in cases of extreme nervousness, in which all attempts at local anesthesia of the dentin had failed. Further experiments with this sedative are therefore highly desirable."

From personal experiments with chloral hydrate (1 gram) and morphin (0.01 gram) for the reduction of sensitivity, we have come to the conclusion that internal medication of this nature in suitable cases is most advantageous. The analgesic effect is noted after from four to five minutes, characterized by a notable reduction in the sensitivity of the dentin, varying in different individuals. In highly excitable persons this effect is frequently noted to a remarkably extensive and pronounced degree. While harmless, this method involves one disadvantage, inasmuch as the certainty of its success is not invariably uniform. Before the induction of either general or local anesthesia, however, it affects most favorably the psychic condition of nervous patients.

**Pulp Extirpation and Root Canal Treatment.**—Local anesthesia for the treatment of teeth with diseased pulps offers some disadvantages. Unless the condition of the tooth in question can be diagnosed with absolute certainty, local anesthesia should be desisted from, since its effect does away with important diagnostic symptoms, especially pain. Healthy pulps can invariably be extirpated painlessly after an injection.

If, for some reason or other, some slight sensitivity in a pulp is encountered after opening into the pulp chamber, pressure anesthesia with a novocain-suprarenin pluglet, after the method described, will quickly abolish all sensation. The immediate filling of root canals is indicated only under certain rare conditions. In pulpitis due to pulp-stones or any other cause, injection is most favorably indicated for the painless exposure of the pulp, the coronal portion of which can be immediately amputated with a sharp spoon excavator of suitable size. Immediate total extirpation and root canal filling, however, is contraindicated in such cases, a few days afterward the pulp stumps should be removed, the root canals cleaned and disinfected, and a root canal filling then inserted.

The immediate filling of root canals under anesthesia is bad practice for the additional reason that pulp tissue clings very tenaciously to the dentinal walls of the canal and cannot be removed in its entirety. Even the pulps in incisors and canines which are so easy to extirpate are frequently torn into shreds, the complete removal of which is most trying and uncertain, not to mention the difficulties involved in extirpation of the pulps of bicuspid and molars. Moreover, the hemorrhage in a root canal is very difficult to arrest. It produces an unsafe edematous zone of demarcation at the apical foramen which disappears only gradually after subsequent periodontitis, and, in case of infection by way of the root canal, leads to suppurative pericementitis which renders the preservation of the tooth very uncertain.

Pulp débris that has not been removed becomes the cause of protracted irritation of pulpitic and pericementitic nature, which can be combated only by means of cauterization. Even granting that there are many teeth which remain quiescent under such conditions, it is a well-known fact that pain in pulps may be of greatly varying intensity. We only need to mention the cases of patients who present putrescent pulps, though they have never suffered any pain. "Shot-gun methods" of pulp and root canal treatment under local anesthesia must be absolutely tabooed, since they will reflect discredit upon a procedure which is invaluable if judiciously applied. "Quick cure" artists, of course, will always attribute any pain following their slipshod treatments to "the injection or the toxicity of novocain."

If, in exceptional cases, the filling of root canals at one sitting becomes necessary, *aqua regia* seems the most suitable of the many drugs recommended for the destruction of pulp remnants and the cleansing of canals. A number of cases treated in this manner for the sake of experiment have all been successful, while treatments with antiformin, formalin solutions, zinc chlorid, sodium and potassium, sulphuric acid, and sodium dioxid were followed by irritations.

**Crown and Bridge Work.**—In crown and bridge work also, local anesthesia is rapidly gaining favor. Numerous minor operations, such as the grinding of vital teeth, the shaping of abutments, the taking of measurements, the fitting of bands, the trying-in and setting of crowns, etc., are so painful that it is most desirable to afford relief to the patient. The mode of injection of novocain-suprarenin solution for this purpose is the same as described in this book. Occasionally, the mucosa and gingival tissue can be successfully anesthetized by the topical application of a thick novocain paste.

**Résumé.**—In a number of systemic diseases, local anesthesia was formerly considered as risky. The low toxicity and blandness of novocain-suprarenin solution, however, has brought about the employment of even 2 per cent. solutions in arteriosclerosis, diabetes, nephritis, diseases of the heart and lungs, anemia, chlorosis, pregnancy and lactation. In diseases of the heart and lungs, cocain is absolutely contraindicated.

In obstinate or highly excitable patients, neurasthenics and hystericals who insists upon general anesthesia, conduction anesthesia is contraindicated, unless consent is obtained following preoperative medication by hyoscine-morphine, as indicated above.

If general anesthesia must be resorted to, analgesia by nitrous oxid and oxygen, ethyl chlorid, ethyl bromid, or ether is preferable to chloroform.

In general, the operator should follow the principle that the simpler the operation, the less risk he should assume.

The patient should possess a certain amount of resistance to render him suitable for local anesthesia. It is therefore important that such a method of injection and such a solution be selected as will produce a minimum of toxicity.

Considering the ever growing enervation of our patients, the sphere of application of local anesthesia is ever widening; even for very minor dental interventions anesthesia is called for. General anesthesia is equivalent to general intoxication, which invariably jeopardizes the patient's life. With our novocain-suprarenin solutions, this risk is precluded, especially in dentistry where the dosage and the quantity of solution lie far below the toxic border.

To quote Braun: "The chief advantage of local anesthesia consists in the possibility of introducing almost unlimited quantities of solution into the body and obtaining a local insensibility of heretofore unthought-of intensity and duration. This possibility has opened the field of surgery to local anesthesia, and has determined its remarkable progress which, even with an improved technique of injection, could never have been achieved with the old drugs. The introduction of novocain and suprarenin was as important an event for local anesthesia as that of cocain.

Local anesthesia, therefore, is the method of choice whenever conditions indicate successful desensitization of the entire field of operation by moderate doses of a readily applied anesthetic; whenever the operator is familiar with the technique and the limitations of this method; and whenever the patient's psychic condition does not absolutely demand narcosis."

### ANESTHESIA IN THE THERAPY OF INFLAMMATION.

For combating inflammatory conditions in the oral cavity Fischer, as early as 1907, recommended the generous use of anesthesia, and first introduced into dentistry a method which had already proved most effective in other branches of medicine.

"The chief object of anesthesia in the therapy of inflammations is to bring the anesthetizing agent in such frequent and intimate contact with the wound that pain is prevented or reduced to a minimum." (Spiess.)

The patient's subjective feeling corresponds exactly to the condition of the wound and the intensity of the inflammation. Whenever

pain is absent or of a mild degree, we may safely conclude that there is no or little inflammation.

In a large number of throat operations, also in surgical interventions in the tongue, the cheeks, and the mucosa of the lips, anesthesia has been therapeutically applied by Spiess in various ways. When superficial analgesia proved insufficient, submucous injections were made for the postoperative treatment of cases in which anesthetic dressings were technically impossible. The object was to anesthetize inflamed tissue and wounds situated in such areas, and to keep both in an analgetic condition for a prolonged period of time.

In minor injuries of the tongue due to accidental biting or to sharp edges and corners of carious teeth, and in the intensely painful desquamations or blisters at the tongue margin, pain rapidly disappears after several applications of an anesthetic agent made at short intervals.

The disagreeable sensations of incipient nasal catarrh are relieved by insufflation of orthoform or novocain into the nasopharyngeal cavity, repeated until normal sensation is reestablished. Coryza can be aborted with absolute certainty in this way. Insufflation or dressings of novocain involve no risk whatever, since novocain is not a habit-forming drug. A great many victims to the cocain habit have been started in their fatal practice by the application of cocain to their nasal mucous membrane by thoughtless physicians.

Minor bruises, lacerations, also wasp- or fly-stings, should be painted with orthoform or novocain in the form of a thick paste, or in strong solution, until all pain has ceased. Redness and swelling will thus be arrested, the wound edges will be smoother, paler, and without sensation, and the wound will undergo rapid healing. By all these observations, extending over a long period of years, it has been established beyond doubt that local anesthetics arrest pain; that wounds when dressed with one of these agents heal without inflammation; and that inflammation, when present, subsides in a very short time.

It has also been found that, together with pain, redness disappears. Heretofore it was impossible by means of antiphlogistics to modify an inflammation at the climax of its development in such a way as to combat redness. With the local anesthetics mentioned this can be

accomplished in a very short time, often within a few minutes; moreover, pain can be absolutely abolished. This rapid abatement of redness can be explained only by assuming a direct relationship between pain and redness, in opposition to Cohnheim's theory. It simply remains to establish:

"1. That in the same way as an irritation of sensory nerves produces hyperemia by way of reflex, so inhibition of this irritation prevents or cures hyperemia.

"2. That therapeutic treatment should be directed exclusively against irritation of the sensory nerves, and that the normal function of bloodvessels should be maintained.

"3. That anesthesia is required only to such a degree as to inhibit reflex action and to prevent in the parts involved any changes induced by the sensory nerves by way of reflex."

All these postulates are fulfilled in anesthetics occurring in the hysterical and the insane. Alienists have noted many such cases in which injuries, burns, and wounds in such patients healed completely without any reaction whatever. Insane patients have torn open the abdominal wound after laparotomy, touched it with unclean fingers, yet made an uneventful and complete recovery.

Hysterical persons can stick pins in their skin without any untoward consequences. In one case of hysteria the patient, who was suffering with general lack of sensitivity, dipped his hands repeatedly in boiling water without being scalded in the least. The explanation may be that the afferent nerves being insensible, could not be stimulated, and the reflexes upon the vasomotor nerves remained inert. Since the influence of the heat was only of short duration, no direct scalding effect was produced upon the tissues, and no hyperemia or inflammation occurred.

Experiments with spinal anesthesia in animals have confirmed these observations; anesthetized tissue, upon being touched with a test-tube filled with boiling water, exhibits no blisters nor even redness.

The sensory sphere is paralyzed not in hysteria only but also in those pathological conditions in which, besides the afferent nerve fibers, the sympathetic nerves, often termed trophic nerves, are affected. Of special interest to us are the cases of gangrene caused by drugs, in which

the above factors probably play a part. If carbolic acid is allowed to act too long and too intensely, the well-known phenomena of thrombosis appear, and not only the conductivity of the afferent fibers is inhibited but the bloodvessels also are paralyzed, and their function is destroyed. Cold of sufficient intensity also will abolish sensation, as is shown by the ether spray. If its influence is unduly prolonged, the vasomotor nerves permeating the vascular walls are directly affected and gangrene ensues.

While anesthetization of the afferent nerves promptly prevents or combats inflammation, all inflammatory phenomena appear more rapidly and severely if the sympathetic nerve branches are paralyzed, as Samuel has proved by animal experimentation.

Pain, which is a specially pronounced specific sensation of discomfort, hence a condition of conscious sensation, undoubtedly intensifies not only general but also local irritability and actual irritation of inflamed areas by conscious and wilful acts; furthermore, by way of unconscious reflexes, *i. e.*, by way of the centripetal (afferent) nerve supply of the irritated brain centres. This, however, is after all not the primary or most important cause of these local conditions. It is, therefore, the first aim of the therapist to reduce the increased local irritability—the cause of the abnormal central processes—either directly or by a general reduction of the normal or pathological sensitivity of the nervous system. In light cases this may be accomplished by very simple measures, *viz.*, by surgical rest of the inflamed parts. Since, however, despite the protection from external stimuli, owing to the continually recurrent action of internal tissue stimuli, local irritability may gradually increase and become excessive, these simple measures are frequently inadequate, and an attempt must be made to modify the local irritability of the tissues themselves by the application of cold or heat, which reduces the disposition to abnormal irritability, and indirectly regulates the blood-supply and the process of repair. For these reasons, Spiess' method is especially efficacious, as it acts in both directions, first, by the thick layer of orthoform or novocain powder protecting the part against external stimuli; second, by directly preventing the irritability of the morbid tissue. The

latter effect is produced to a notable degree by morphin, which is intended to act not as an hypnotic but merely as a sedative; for it is improbable that morphin attacks the central nervous system primarily. Such direct action upon the nervous centre is peculiar to chloroform and ether, while morphin affects above all the peripheral, the integumental nerves, and reduces the irritability of the central nervous system by acting from the periphery. Simultaneously with the altered irritability of the tissue the healing process commences its favorable course, not because pain is abolished or the pain-conducting nerves are paralyzed, but because the source of pain is blocked and the cause of increased irritability is removed, so that the nerves are no longer abnormally stimulated.

The drugs which reduce irritability act best in the early stages of inflammation, or when the equilibrium of the tissues is tending to return to normal. The favorable action of carbolic acid, locally applied, must be attributed chiefly to its anesthetizing property, and it appears that other drugs, the favorable action of which was formerly attributed to their disinfectant power, possess the same sedative effect. The local application of morphin to inflamed tissue denuded of epithelium exerts a favorable influence, if the powder is allowed to dissolve on the mucosa, or if a few drops of a strong solution are allowed to be absorbed.

"No inflammation will develop if the reflexes conveyed from the area of inflammation by way of the afferent sensory nerves are successfully inhibited by anesthesia. Rapid healing of inflammation is induced by anesthesia of the centre of inflammation, if only the sensory nerves are anesthetized, and the normal function of the sympathetic (vasomotor) nerves is not interfered with." (Spiess.)

At all events, it is of great importance to prevent external irritation, and, if this is no longer possible, to treat the area favoring internal irritation in such a way as to reduce the hypersensitivity of the tissues to a state of normal sensitivity, which is accomplished by anesthetics.

In all cases which we have had occasion to observe, painlessness lasted until the termination of treatment. In prophylactically treated cases no inflammation of extraction wounds set in, which otherwise would surely have occurred, considering the severe nature of the opera-

tion. It might be suggested that antiseptic applications alone would suffice to bring about an alleviation of pain and a reduction of inflammation. Judging from experience, however, the new method of wound therapy by tamponade with novocain, orthoform or anesthesin marks a great improvement over the old procedures, inasmuch as no postoperative pain arises, and the healing process is rapid and uneventful following extractions or other surgical operations.

It is important to emphasize that local anesthesia is as valuable in the prophylaxis as in the curative treatment of inflammation, and this relatively novel method of treating inflamed tissues will permit of further elaboration. The extensive application of local anesthesia will bring us nearer to one of our foremost aims, which is, to make our operations as well as postoperative treatment painless, thereby hastening the processs of repair in tissue lesions.



## PART III.

### TECHNIQUE OF LOCAL ANESTHESIA.

#### ANATOMICAL STRUCTURE OF THE OSSEOUS FRAME OF THE MAXILLÆ.

THE osseous frame of the jaws, which is formed by the maxilla and the mandible, possesses a number of peculiarities which are of special importance for the technique of local anesthesia and the diffusion of injected solutions. The pressure exerted in injecting serves to force the anesthetic through the *canaliculi* in the outer surface of the bone into the interior of the *alveolus*, whereby the nerves supplying the teeth are paralyzed. It is the purpose of the following pages to demonstrate at which points of the maxillary apparatus these areas favorable for diffusion are constantly found.

The bony surfaces of the jaws are subject to great variations depending upon age and individuality. In youth, the bone is far more readily penetrated by solutions than in adult and senile age. Furthermore, the porosity of the bone is more or less distinctly pronounced in different areas and in different individuals. The nerve fibers largely distributed below the cortical layer of the jaw bone, especially in the maxilla, become insensible by the distribution of a 2 per cent. novocain-suprarenin solution over the osseous surface and by its subsequent penetration through the minute canals into the interior of the bone, where all the tissues are inundated to a considerable distance. A high per cent. solution, therefore, has a long distance effect which is of great importance for dental anesthesia. If we succeed in making a good subcutaneous injection—in the maxillæ one might almost speak of a subperiosteal injection, then anesthesia of the deeper tissue strata,

bone and teeth, is assured. For dental purposes, therefore, we can utilize subcutaneous injections which incidentally act as subperiosteal injection, unless one prefers to induce anesthesia at the point of exit of the large trigeminal trunks at the base of the skull, as required for deep surgical interventions, or to resort to conduction anesthesia.

**Anterior Surfaces of the Maxillary Bones.**—If we examine the jaws of a macerated skull, we note that *spongiose*, greatly *canaliculated* or *cancellated* osseous tissue alternates with *cortical* bone which presents but few canaliculi.

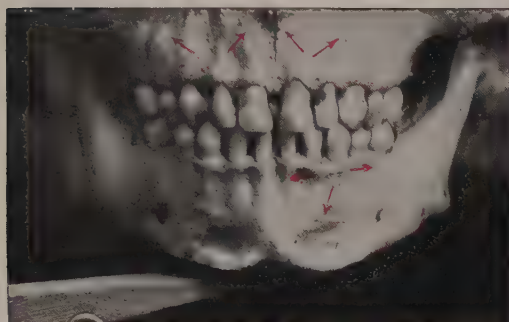
In the maxilla the compact substance extends chiefly labially and buccally, but is interrupted in most skulls by definite and invariably present cancellous areas, which are of the greatest importance in local anesthesia. For only in these areas is it possible to force the solution under moderate pressure and without causing lesions through the bone into the alveolus, and to infiltrate and anesthetize the entire profusely innervated environment of the tooth root.

In Figs. 17 to 23 the anterior views of several skulls of persons of different sex and age are presented in order to show the various stages in the development of the sieve-like, cancellous or spongiose areas, and their varying extent. Red arrows indicate specially favorable areas which guarantee a good diffusion of the solution. Fig. 17 shows the skull of a child, aged seven years, Fig. 18, the skull of a man, aged twenty years, in which the characteristic cancellous areas plainly appear.

In the maxilla as well as in the mandible the *alveolar ridges* at the necks of the teeth always exhibit sieve-like perforations, as does the depression at the *anterior nasal spine*, or incisive fossa in the region of the root apices of the upper central incisors. In the mandible the cancellous areas are limited to the anterior portion in the region of the chin, or *mental region* (see Figs. 18 and 23). Mesially to the root apex of the canine, in the *mental fossa*, on either side, groups of small *foramina* are distributed sometimes extending up to the alveolar ridge (see Figs. 17, 18, 22 and 23). Especially Fig. 23 shows plainly how finely perforated the *mental portion* may be. The jaws of *older persons*, especially in the mandibular portions, show very few perforations (see Figs. 20 and 21).

The lateral aspect of the same skulls shows that in the maxilla, in the molar region, the cancellous areas become fewer, while in the mandible they are lacking entirely (see Figs. 24 to 30). In the mandible the alveolar ridge only is perforated, while toward the base a thick cor-

FIG. 17



Maxillæ of child, aged seven years, showing extensive cancellous areas.

FIG. 18



Maxillæ of young man, showing extensive cancellous areas.

FIG. 19



Maxillæ of young person, showing extensive cancellous areas.

FIG. 20



Maxillæ of old person, showing few perforations.

tical layer prevails. The *youthful jaw* (see Fig. 24) exhibits the widest extent of cancellous bone; even the mandible in this skull is traversed by numerous canaliculi. Fig. 25 gives a good view of the cancellous fossa at the level of the *root of the upper canine*; this *canine fossa* in all

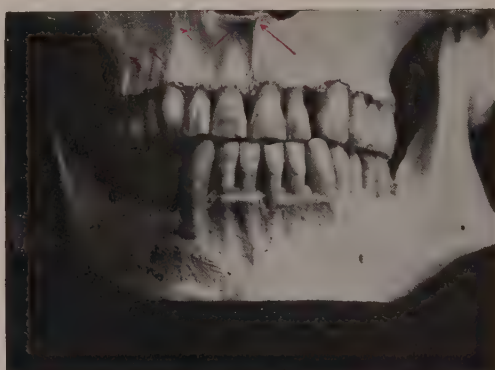
skulls is of more or less canaliculated structure. Generally the apical region of the upper teeth exhibits a canaliculated area, while the middle root portion is protected by a dense cortical layer (see Figs. 26 to 28).

FIG. 21



Maxillæ of old person, showing few perforations.

FIG. 22



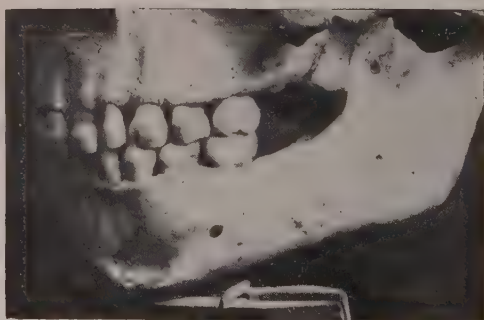
Maxillæ of adult, showing numerous perforations.

FIG. 23



Maxillæ of adult, showing numerous perforations.

FIG. 24



Lateral view of Fig. 17.

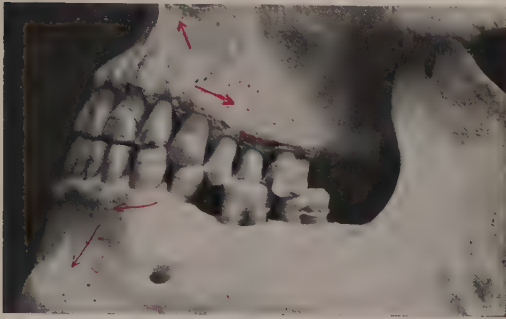
The upper *bicuspid*s only seem to be overlaid to their entire length by uniformly spongiose bone.

The upper molars are covered by an osseous plate of chiefly cortical character, which above the third molars usually is again liberally perforated, as a glance at the tuberosity in Fig. 31 plainly shows.

*S. A. Hussey Jr.*

The anterior surfaces of the maxillæ present two very important large foramina which permit the passage of important nerves and vessels, namely, in the maxilla the *infraorbital foramen* above the root of the first bicuspid, in the mandible the *mental foramen* below and between the first and second bicuspid.

FIG. 25



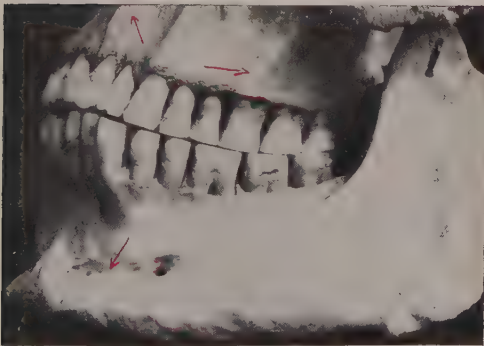
Lateral view of Fig. 18.

FIG. 26



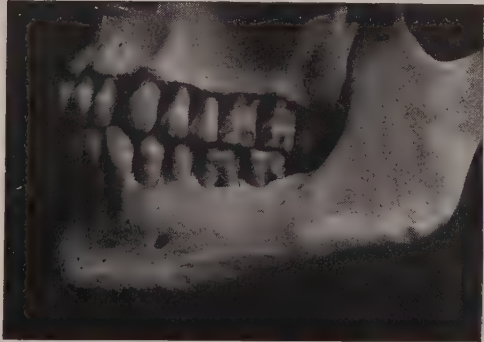
Lateral view of Fig. 19.

FIG. 27



Lateral view of Fig. 20.

FIG. 28



Lateral view of Fig. 21.

**Posterior Surfaces of the Maxillary Bones.**—The *posterior surface* of the maxilla is traversed by numerous canals which are distributed very regularly. Fig. 38 shows the palatal view of the maxilla. The hard palate in its anterior and median portions is seen to be closely perforated. In the molar region the canaliculi in the alveolar bone decrease in

number at the middle portion of the roots, and gradually disappear toward the tuberosity. In this region we find the large *posterior palatine foramen*.

FIG. 29



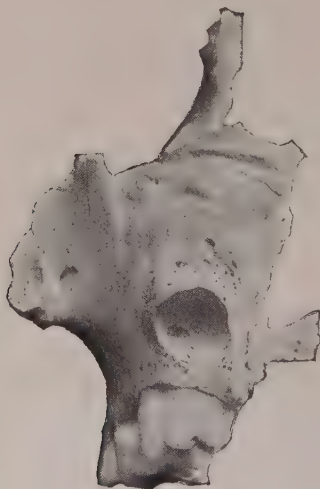
Lateral view of Fig. 22.

FIG. 30



Lateral view of Fig. 23.

FIG. 31



Extent of cancellous bony tissue at the maxillary tuberosity. Above the empty alveolus of the third molar, large foramina are seen through which the NS solution can enter the bone.

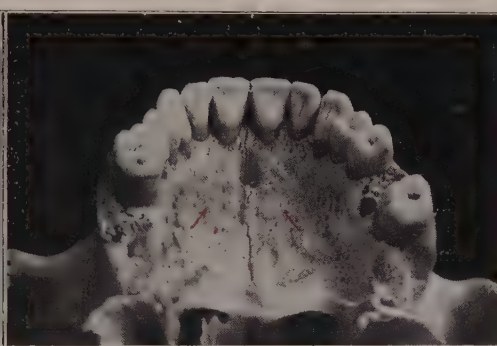
These conditions are clearly shown in Figs. 32 to 35. These illustrations furthermore disclose the fact that the cancellous areas in the

*Fred S. Caddell*

palatal surface vary in different individuals. Figs. 32 and 33 represent densely perforated *youthful skulls*; Figs. 34 and 35 the considerably less cancellated maxillæ of *older subjects*.

FIG. 32

FIG. 33

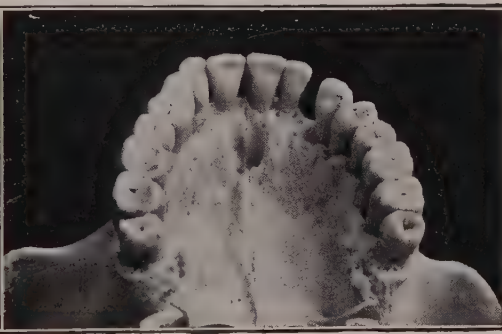
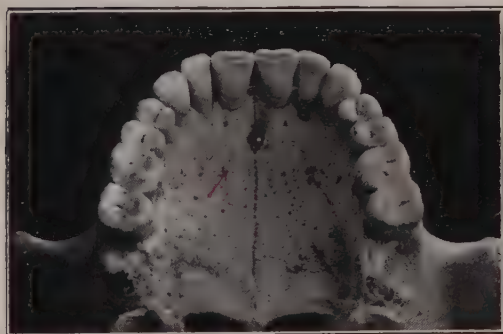


Palatal surface of maxilla of youthful person, showing extensive cancellous areas.

Palatal surface of maxilla of youthful person, showing extensive cancellous areas.

FIG. 34

FIG. 35

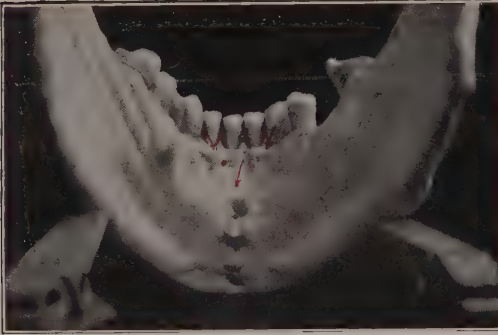


Palatal surface of maxilla of adult, showing few perforations.

Palatal surface of maxilla of old person, showing few perforations.

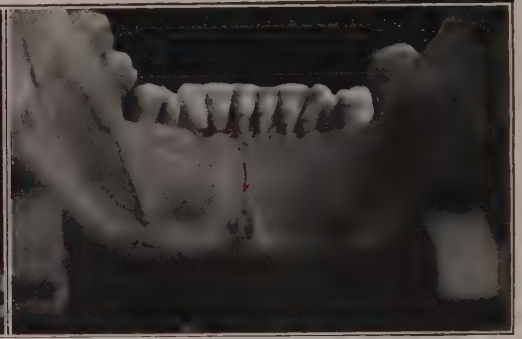
In the *palatal surface* of the maxilla we find two well-marked large foramina, the *incisive* or *anterior palatine foramen* behind the central incisors and the *posterior palatine foramina* at the level of the third molars, as clearly illustrated in Fig. 38. (See also Figs. 32 to 35.)

FIG. 36



Inner surface of mandible, showing dense bone.

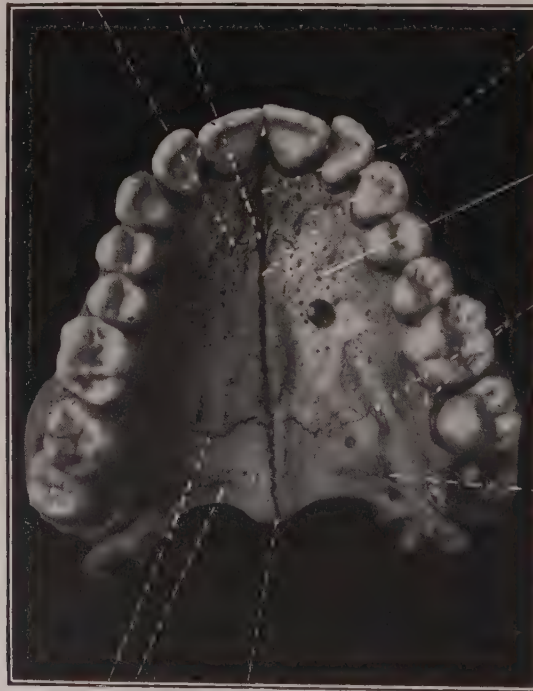
FIG. 37



Foramina are noted at the symphysis.

FIG. 38

*Incisive or anterior  
palatine canal*  
*Incisive suture*



*Transterse palatine  
suture*

*Posterior nasal spine  
Portion of horizontal plate  
of palate bone*

View of palatal surface of maxilla.

**Mandible.**—The lingual surface of the mandible, in contradistinction to the maxilla, is entirely non-canalculated, it represents a hard, sclerous section of bone which is unsuitable for infiltration.

Only at the *internal genial tubercles*, or *mental spines*, some partly fair-sized *foramina* are noted which frequently reach to the alveolar ridge, and in transverse sections are seen to communicate with the mandibular canal (see Fig. 39; also Figs. 36 and 37), while the entire posterior portion up to the third molars is almost impenetrable and non-canalicular (see Fig. 40). Above the inner angle of the jaw however, in the ascending ramus we find a very large aperture, namely,

FIG. 39



Section through symphysis of mandible. Some of the foramina on the inner surface communicate with the inferior dental canal.

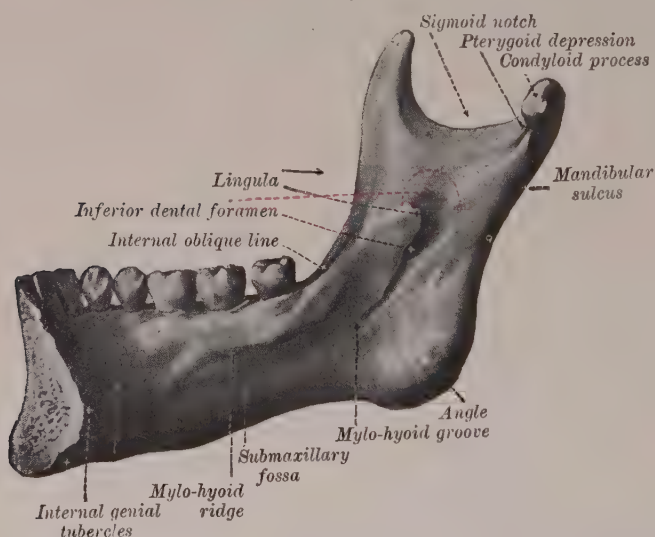
the *mandibular* or *inferior dental foramen* (see Figs. 40 to 42), which is important for conduction anesthesia of the mandible.

To recapitulate, the bone of the jaws exhibits upon its surfaces, in the maxilla more than in the mandible, certain spongiose areas which are favorable for the diffusion of solutions. These spongiose areas are more evident in youth than in old age, which fact proves infiltration anesthesia to be indicated in youthful subjects, while with advancing age conduction anesthesia is the method of predilection.

**The Mandibular Sulcus and the Mandibular or Inferior Dental Foramen.**—In adults the *ascending ramus* begins a little behind the third molar, sometimes in an abruptly ascending surface. At its basis,

when regarded as resting upon the alveolar process, the ascending ramus, in front view, shows an outer buccal *anterior ridge*, representing the last ascending portion of the *external oblique line* (see Figs. 40 to 44). About 0.5 cm. inward and backward of this line runs a ridge bordering the lingual surface, the *internal oblique line*, which gradually loses itself in the posterior section of the coronoid process. Between these two lines in the bony surface is situated a more or less pronounced deep groove which we might call the *retromolar fossa*

FIG. 40



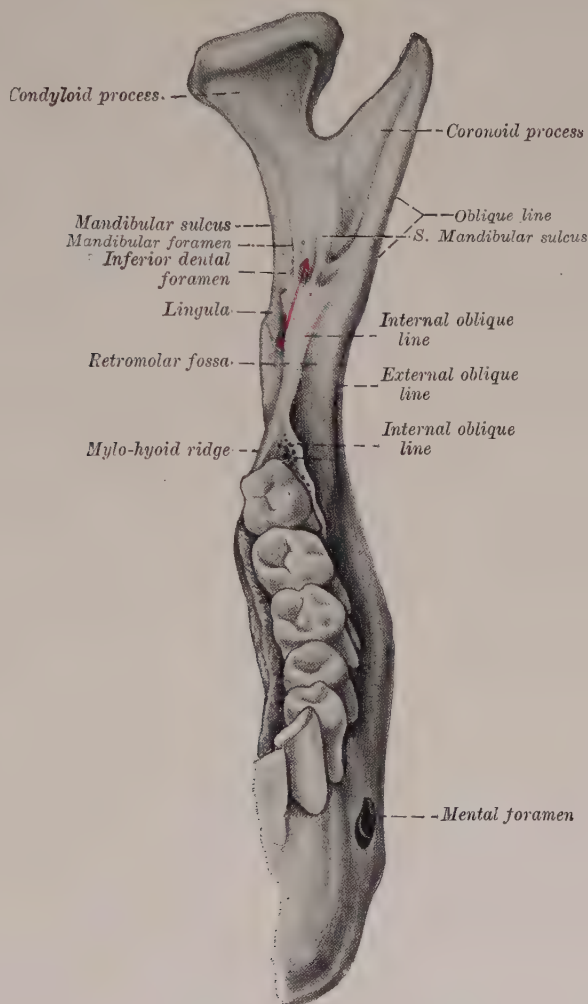
Side view of inner surface of right half of mandible. The red arrow indicates the direction in which the needles should be pushed forward over the lingula. The red circle indicates the area of injection.

(see Figs. 41, 43, and 44). This fossa, which is covered by a thin layer of mucous membrane, serves as the most reliable place of orientation for the palpating finger before inducing conduction anesthesia of the mandible.

About the middle of the internal surface of the ascending ramus the large *mandibular* or *inferior dental foramen* is situated (see Figs. 40 to 42, and 44), which marks the starting-point of the *mylohyoid groove* which runs obliquely downward and anteriorly (see Figs. 40, 42,

and 44). The orifice of the foramen itself is protected anteriorly to a varying extent by a spiculum of bone of varying size, the *mandibular*

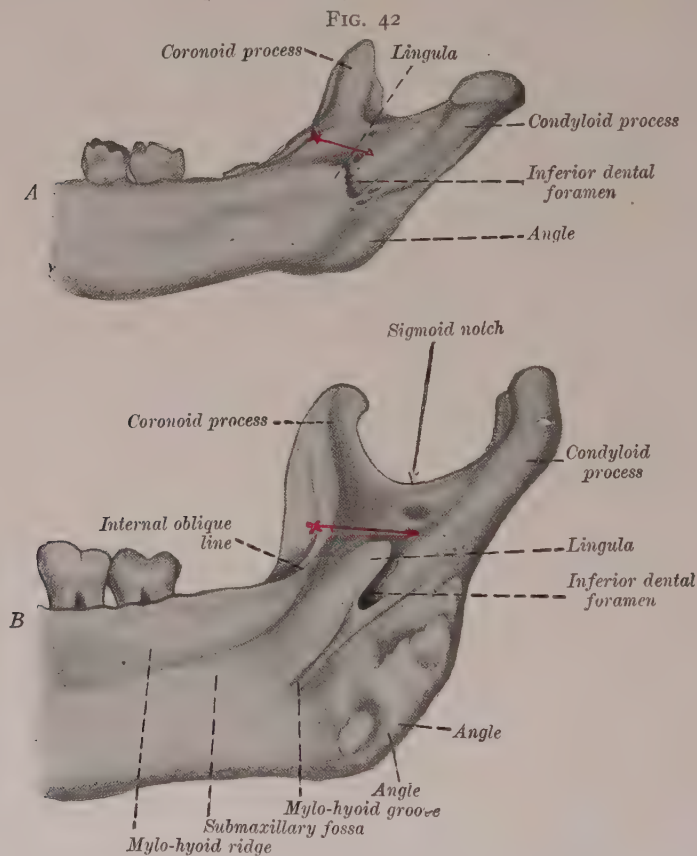
FIG. 41



Relationship of the ascending ramus to the body of the jaw. The red arrow indicates the direction in which the needle should be advanced to the inferior dental foramen.

*lingula* (see Figs. 40, 42, and 44). This lingula may be developed as a pointed plate of bone or as a tongue-like cover, or only as a thickened

process on the anterior margin (see Fig. 42). Sometimes the lingula is connected with the lower free margin of the orifice of the mandibular canal by a small bony spiculum or bridge.



Variations of the mandibular or inferior dental foramen at different ages: *A*, mandible of a child, aged seven years (the needle should be inclined slightly downward). *B*, mandible of a male adult, aged thirty years. The red arrows indicate the direction of the needle.

In adults the *mandibular foramen* is always situated above the alveolar ridge and in a horizontal plane about 1.5 cm. from the *anterior border* of the ascending ramus of the jaw, the *external oblique line* (see Figs. 41 and 44). The internal aspect of the ascending ramus is inclined posteriorly and pharyngeally, forming an angle with the continuation



The mandibular foramen is continued posteriorly and upward by a shallow groove of varying depth and extent, which Spee and others have named the *mandibular sulcus* (see Figs. 40 to 44). By its anatomic nature this sulcus is the most favorable place for the reception of the solution injected in conduction anesthesia of the mandible. The needle is therefore inserted a little above the lingula, and the solution is deposited in this sulcus (see Figs. 43 and 44).

### THE MINUTE STRUCTURE OF THE ALVEOLAR PROCESS.

**Structure of the Osseous Substance.**—In ground sections of the alveolar processes of either jaw two different layers of osseous tissue

FIG. 45  
*Spongiose alveolar margin*



Extent of spongiose or cancellous bone within an exposed alveolus.

are continually found, namely, the sparingly canaliculated substance, the *compact substance*, and the highly cancellated and medullated

#### EXPLANATION OF ABBREVIATIONS IN FIG. 46.

$_2B$ , lower left second bicuspid;  $_1B$ , lower left first bicuspid;  $_1C$ , lower left canine;  $_2I$ , lower left lateral incisor;  $_1I$ , lower left central incisor;  $I_1$ , lower right central incisor;  $I_2$ , lower right lateral incisor;  $C_1$ , lower right canine; *M. F.*, mental foramen; *C.m.*, mandibular canal; *F. C.*, facial cortical layer; *L. L.*, lingual cortical layer; *pal. Cort.*, palatal cortical layer; *E. S.*, extraction scar;  $C^1$ , upper right canine;  $I^2$ , upper right lateral incisor;  $I^1$ , upper right central incisor;  $B^2$ , upper right second bicuspid; *Spong.*, spongiose (cancellous) bone; *Cort.*, cortical layer;  $M_2$ , lower right second molar;  $M_3$ , lower right third molar;  $B^1$ , upper right first bicuspid;  $M^2$ , upper right second molar;  $M^3$ , upper right third molar;  $M^1$ , upper right first molar; *Cort. pal.*, palatal cortical layer; *Tuber. max.*, maxillary tuberosity.

10 C. m. Cort. Cort. C. m. 11 Alveoli  $M_2$  Alv. Sept. 12 Alveolus  $M_3$  Alv. Sept. Alveolus  $M_2$  13 Alveolus  $M_3$

14  $I_2$   $C^1$   $B^1$   $B^2$   $M^2$   $M^3$  Cort. C. m. C. m. Cort. 15  $I_2$   $C^1$   $B^1$   $B^2$   $M^2$   $M^3$  Cort. pal. 16  $I_2$   $C^1$   $B^1$   $B^2$   $E. S.$  Alveolar margin pal. Cort. F. C. Spong. 17  $C^1$  F. C. Spong. pal. Cort. Spong. 18 Spong.  $C^1$  F. C. 19 F. C. Spong. 20 Alveolus of  $B^1$  Alveolar margin Septum Alveolar base pal. Cort. Spong.

Nasal wall

Horizontal and vertical sections of the alveolar process in the maxilla and mandible.

tissue, the *spongiose substance*. The former in the *mandible* shows a solidly arranged periphery, its thickness varying with age and with the long diameter of the bone. The spongiose substance which occupies the interior of this solid cortical capsule resembles a sponge in the arrangement of the individual lamellæ and rods. These osseous rods are generally so arranged in regard to direction as to radiate inward from the cortical layer (see Fig. 46, Nos. 1 to 20).

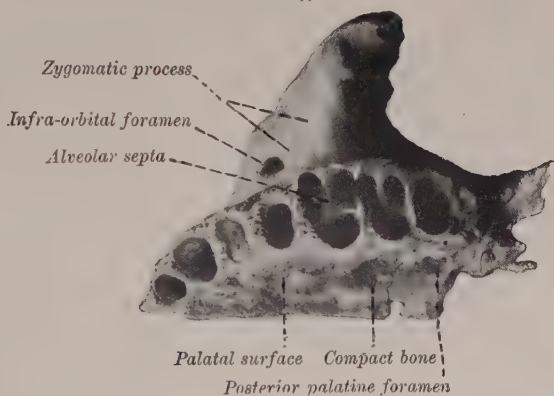
Toldt attributes this architecture of bone partly to an intracartilaginous ossification, partly to the normal developmental processes (apposition and resorption) of the surrounding compact layer. With advancing age the spongiose medullated spaces increase, while the osseous supports of the teeth decrease, so that the densifying compact substance gradually closes in upon a space of little internal resistance.

The *dental alveolus* may be regarded as a crater-shaped depression in the spongiose substance consisting of highly porous osseous tissue, in which the root is contained (see Fig. 46, No. 19; Fig. 49, Nos. 17 and 19). The individual alveoli are separated by *septa*, consisting of thin and porous lamellæ from two approximating alveoli and of spongiose tissue developed between the latter (see Figs. 46, 47 and 49). The alveoli of the upper bicuspid, especially the first, also those of the lower bicuspid in their fundus, contain ridge-like eminences, *septal processes*, which fit into the longitudinal depressions in the roots of these teeth. The *alveolar walls* always exhibit fine, cribriform, sieve-like perforations, which increase in number and diameter toward the upper margin (see Figs. 46, 47 and 49).

These perforations, which are always present in varying number in the alveolar ridge and permit of lively metabolism, are our aids in infiltration anesthesia, because they permit of diffusion of the anesthetic solution to the nerve loops circling and terminating in the teeth. Fig. 46, Nos. 1 to 20, shows a number of bone sections in which the various relations of dental roots to their alveoli, and the structure of the jaws themselves, can be studied. Nos. 1 to 5 illustrate lamellar portions of the anterior section of the mandible from the left second bicuspid to the right canine.

Besides the instructive transverse sections of roots, we can trace in No. 2 the gradually increasing thickness of the outer and inner cortical layers, and study the manner in which, between these, the spongiose layers are arranged around the bodies of the roots. In No. 4 only the apical portions of the long roots of the canines can be seen, while in No. 5 the widely cancellated tissue appears in the proximity of the mandibular canal, which, on the left, communicates through the exposed mental foramen with the anterior surface. While most roots are surrounded with spongiose substance, the roots of the canines are gripped by the cortical layer, which in this region bulges remarkably; this condition contributes largely to the firmness of the supporting abutments of the normal denture, namely, the canines.

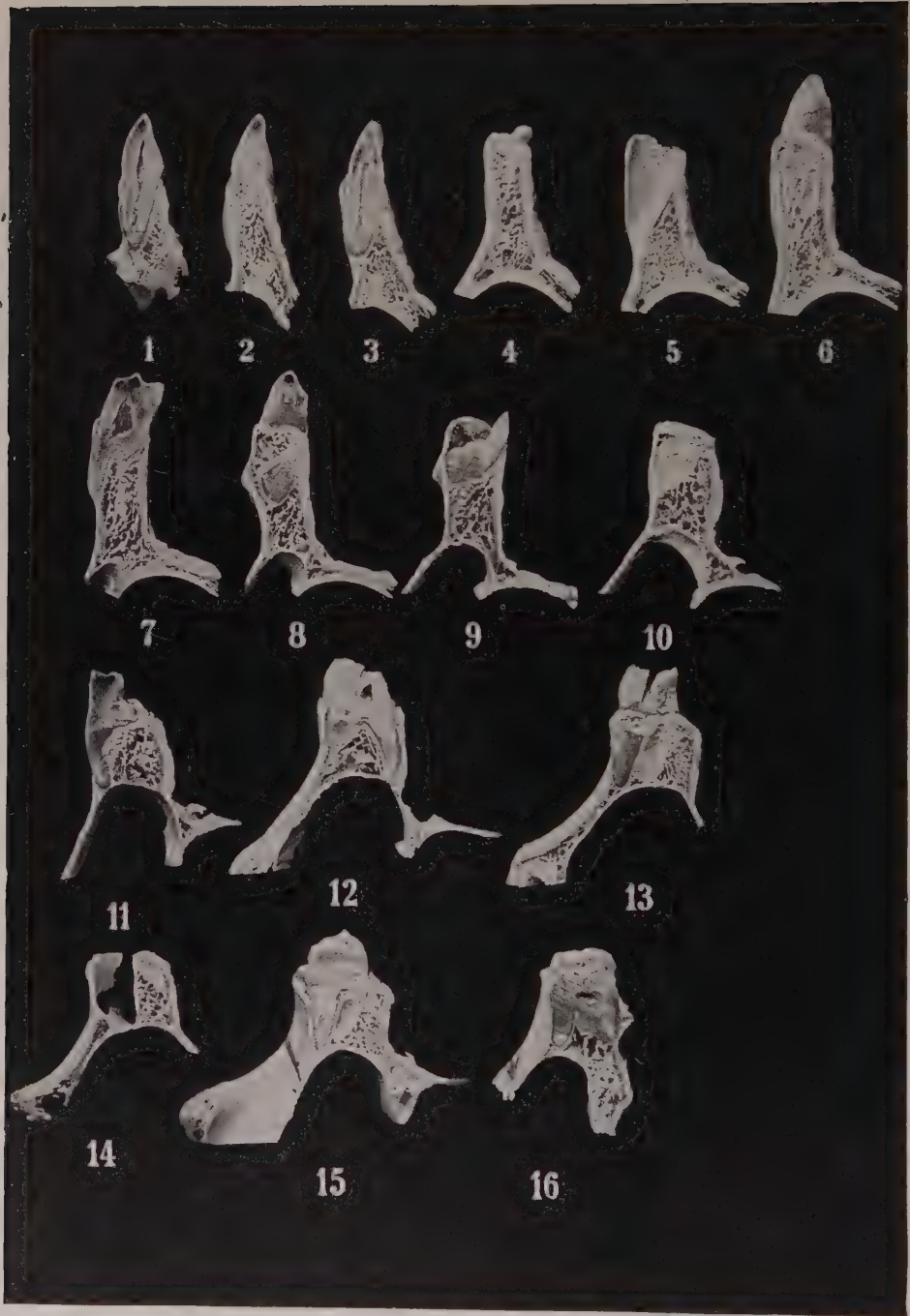
FIG. 47



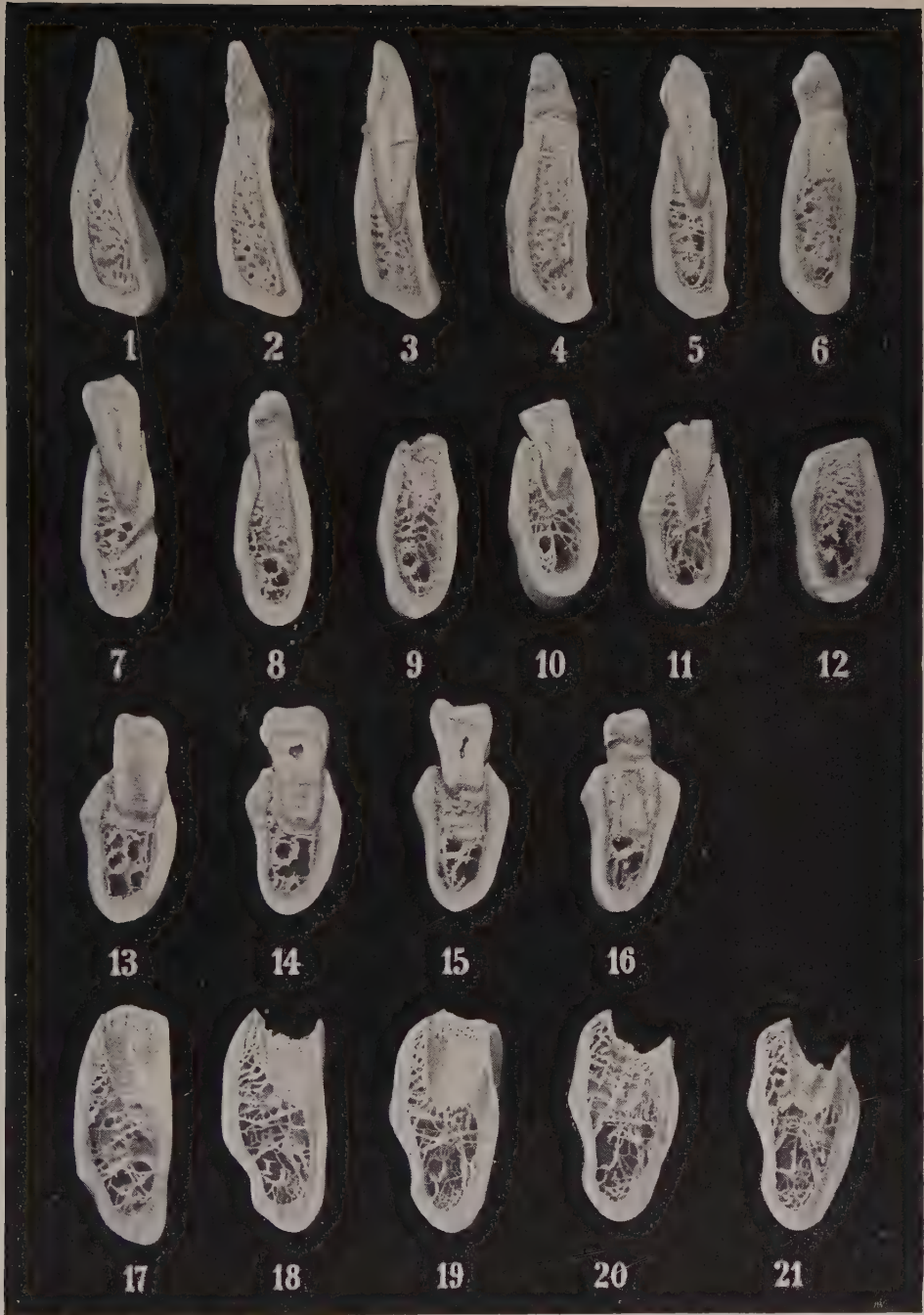
View of cancellous alveolar margin of maxilla. The alveolar septa and margins are densely cancellated.

The same condition is plainly shown in Fig. 46, No. 7, which, like Nos. 8, 9, 15 and 16, illustrates additionally the organization of an old extraction wound into spongiose substance (see Nos. 8 and 9, between  $C^1$  and  $B^2$ , Nos. 15 and 16, between  $B^2$  and  $M^1$ ). Nos. 14 to 18 present the structural details of one maxillary half, showing that the cortical layers are here of a considerably more delicate development than in the mandible. The palatine cortical layer also is seen to be canaliculated. In No. 19 it is further seen that the cortical

FIG 48



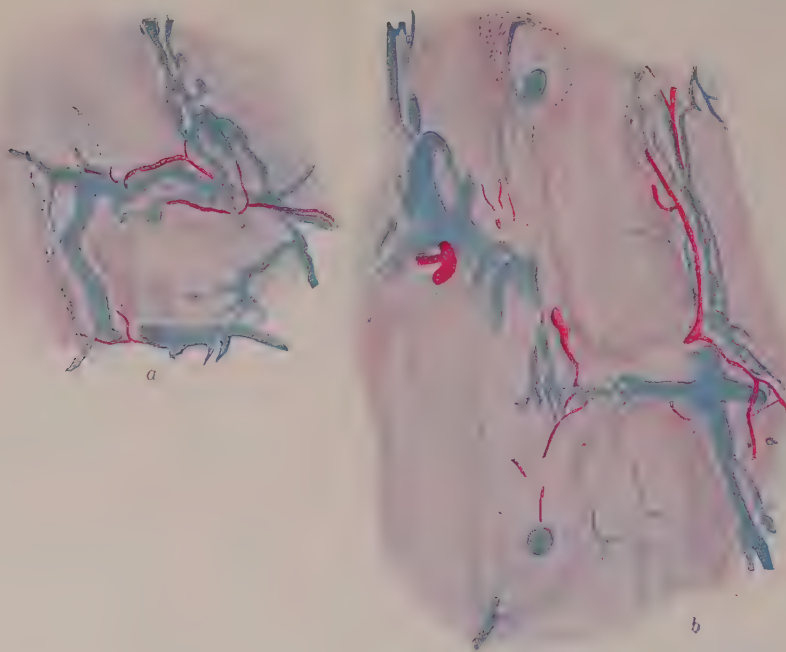
Vertical sections through the alveolar process of the maxilla. Left side, the facial surface; right side the lingual surface; 1 to 4, incisors; 5 and 6, canine; 7 to 10, bicuspid; 11 to 16, molars.



Vertical sections through the alveolar process of the mandible. Left side, the lingual surface; right side, the facial surface: 1 to 4, incisors and canine; 5 to 9, bicuspid; 10 to 16, molars; 17 to 21, alveoli of molars from another skull.

layers covering the posterior buccal and palatal surfaces of the maxilla may increase or decrease in thickness. While the buccal surface starting from the alveolar margin often increases from a delicate stratum to a thick cortical layer, the palatal covering is rather thick at the alveolar margin, whence it gradually tapers. Fig. 45 shows the open alveoli of an upper first molar; this illustration again emphasizes the fact that the most favorable conditions for diffusion exist at the alveolar margin.

FIG. 50



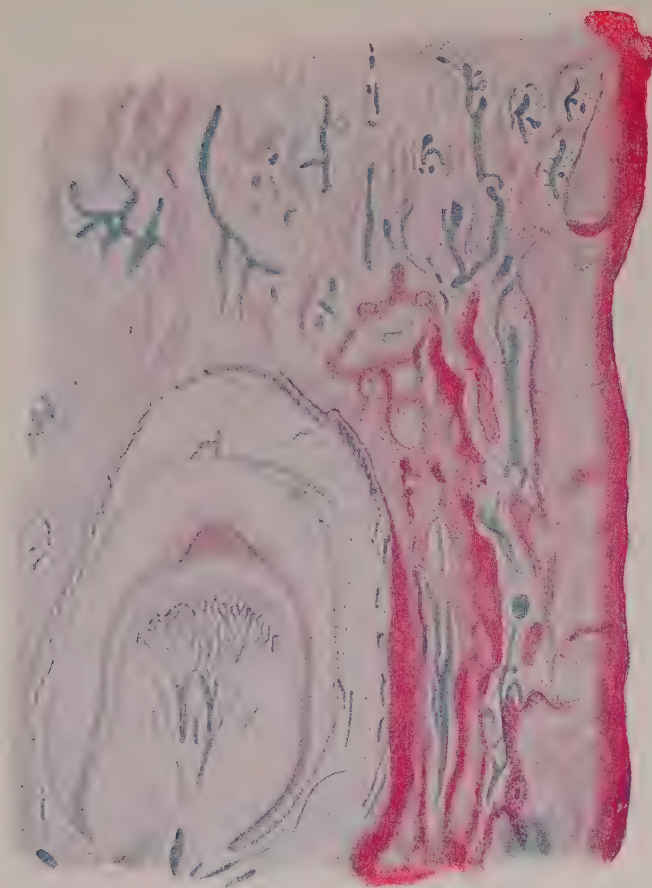
Bloodvessels (blue) and lymph vessels (red) in spongiöse substance of maxillæ.

In order still further to elucidate the conditions for diffusion in the maxillary bones, we have made special vertical sections of the maxilla and the mandible, as shown in Figs. 48 and 49.

*Maxilla.*—In Fig. 48, Nos. 1 to 16, the relationship of the upper teeth to the alveolar process is illustrated. The left side of each of these sections represents the facial; the right, the palatal surface.

Nos. 1 to 6 show the anterior teeth including the canine; Nos. 7 to 10, the bicuspid; Nos. 11 to 16, the molars. All these illustrations present on the palatal surface a broad osseous layer, which, on the facial surface, is delicate and lamellar for the greater part, and, up to the

FIG. 51

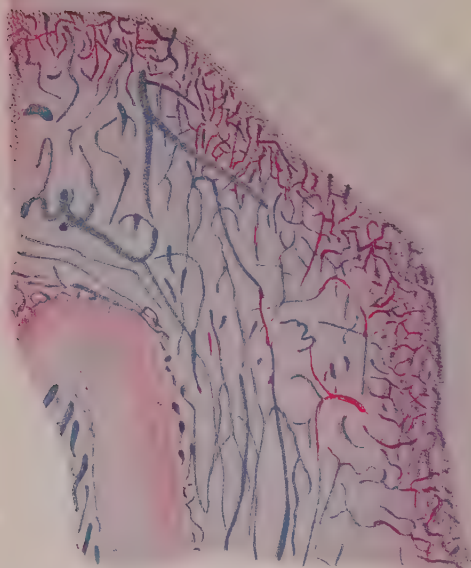


Diffusion of injected staining solution (red) within the bony alveolar process. (Animal experiment.)

bicuspid is specially thin in the proximity of the root apices, which area is generally richly cancellated. It is here, therefore, that the best possible diffusion can be obtained. The roots of the molars frequently are covered with but a thin lamella, which is, however, almost

non-canalculated, and increases in thickness in the third molar region. This tooth, by way of compensation, is surrounded at its root apices by richly cancellated bone, so that it can be perfectly well anesthetized by inserting the needle high up on the gum.

FIG. 52



Appearance of red stain particles within the pulp capillaries (vessels blue).

*Mandible.*—Sections through the mandible plainly show the massive nature of the cortical layer on either side (see Fig. 49). While in the anterior teeth the facial surface of the bone (on the right in the illustrations) is of relatively thin structure, its thickness increases considerably from the bicuspid on, and at the molars (Nos. 10 to 16) attains the same proportions as the lingual surface. Though in the mandible local anesthesia by infiltration is of little value, it can be effected by injection at the cervical margin of the gum, because the alveolar ridges in all lower teeth are of spongiouse character, as illustrated

in Figs. 46 and 48. Fine, spongiöse, cancellous area in the alveoli, even in the molars, is limited, however, to the upper marginal portion, as illustrated in Fig. 49, Nos. 17 to 21, also in Fig. 46.

The foregoing renders it sufficiently apparent that the technique of injection depends not only upon the nerve supply of the masticatory apparatus but also to a great extent upon the character of the bony substance. We shall have occasion to prove that the technique of local anesthesia as demonstrated subsequently is based on these anatomical principles, and for that very reason guarantees such a high degree of perfection and safety.

**Details of Diffusion.**—In order to establish the velocity and manner of diffusion of solutions injected in the jaws, we have injected the periosteum of the maxilla and the mandible in various animals, such as cats, with isotonic staining solutions, using the same technique as for local anesthesia. In all cases the cancellated bone was permeated, and, where cortical substance was present, the red carmine solution penetrated by way of the foramina (see Fig. 50). Spongiöse cancellous bone tissue absorbs the stain with uniform avidity, permitting it to penetrate into the medullary spaces (see Fig. 51). In most cases the interior of the jaw was entirely permeated with the colored solution in five minutes, the pulp within from six to eight minutes. The capillaries of the pulp at the odontoblastic layer are seen to be filled with particles of stain (see Fig. 52), while within the osseous canaliculi red-stained lymph vessels are found chiefly in perivascular arrangement (see Fig. 50). This seems conclusive proof that an isotonic solution, such as the novocain-suprarenin solution advocated, reaches the interior of the alveolar process in a short time. Its diffusion is most rapid and extensive in spongiöse substance, while in cortical areas it proceeds only by way of the few and generally large foramina.

## THE NERVE SUPPLY OF THE MASTICATORY APPARATUS.

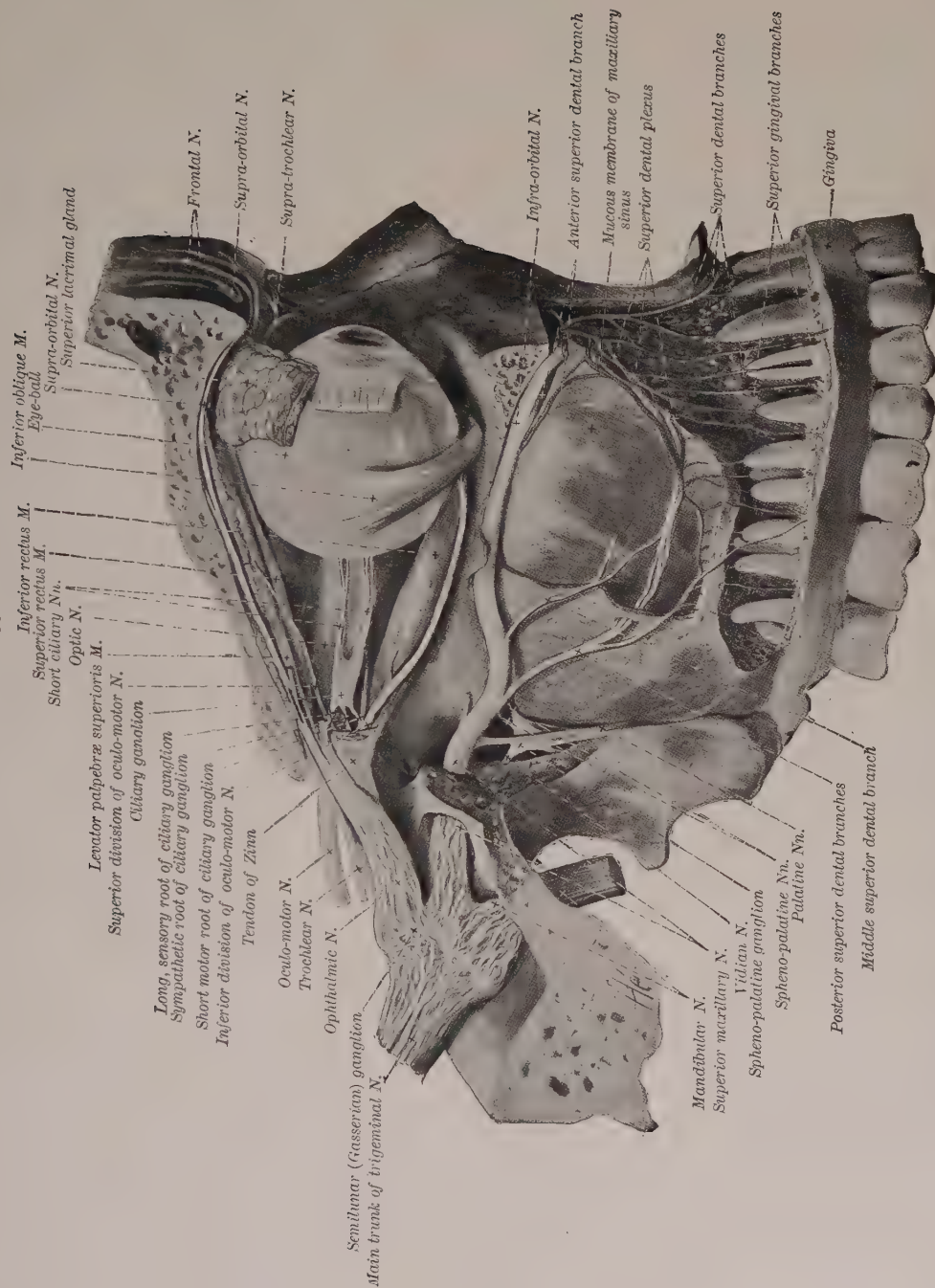
The sensibility of the masticatory apparatus is controlled by the fifth cranial nerve, the *trifacial* or the *trigeminal*.

The trigeminal nerve arises by a ventral, smaller, motor root, and a dorsal, larger, sensory root at the pons Varolii, and extends anteriorly to the apex of the petrous portion of the temporal bone (see Fig. 53). Here the *sensory root* forms the large *semilunar* or *Gasserian ganglion*, from which proceed the three main branches, the *ophthalmic*, the *maxillary*, and the *mandibular* (see Fig. 54). The *motor root* passes independently beneath the ganglion to the *third division*, which, being a *mixed* nerve consisting of *sensory* and *motor* fibers, is distinguished from the exclusively sensory *first* and *second divisions*.

**The Ophthalmic Nerve.**—The *first* or *ophthalmic division* of the trigeminus passes from the *Gasserian ganglion* through the superior orbital or sphenoidal fissure to the *orbit*. It is divided into three branches, *lacrimal*, *frontal*, and *nasal*. The *lacrimal nerve* passes forward along the lateral wall of the orbit at the upper border of the external rectus muscle, and supplies the lacrimal gland, the distal corner of the eye, and the conjunctiva. The *frontal nerve* runs forward under the roof of the orbit, and gives off two branches, the *supraorbital nerve*, and the *supratrochlear nerve*. The *nasal nerve* gives off a long branch to the ciliary ganglion, also the *long ciliary nerves* to the posterior portion of the sclera. It then continues to the median wall of the orbit, giving off the *posterior ethmoidal nerve* to the posterior ethmoidal cells, and the *infratrochlear nerve* to the mesial angle of the eye, supplying the integument of the eyelids, and the lacrimal sac. The *ciliary ganglion*, which also belongs to the first division of the trigeminus, is situated in the posterior third of the orbit laterally of the optic nerve (second cranial nerve), and has three roots, one short *motor root*, one long *sensory root*, and one *sympathetic root* (see Fig. 53).

**The Maxillary Nerve.**—The *second* or *maxillary division* of the trigeminus passes from the *Gasserian ganglion* through the foramen rotundum to the sphenomaxillary fossa, and thence becomes the *infraorbital* nerve. Its branches are *orbital* or *temporomalar branch*, *infraorbital*, with the *posterior*, *middle*, and *anterior-superior dental branches*, and the *sphenopalatine branch* (see Figs. 53, 54, 56, and 57).

FIG. 53



Nerves of the right orbit and maxilla. The greater wing of the sphenoid bone and the lateral wall of the orbit have been removed completely, the roof of the orbit and the maxillary plate partly, the external rectus muscle entirely. (Spalteholz.)

Close to the sphenopalatine foramen lies the *sphenopalatine* or *Meckel's ganglion*, consisting of *sensory* (the sphenopalatine branches), *motor*, and *sympathetic roots* (the Vidian nerve). From the ganglion the *sensory nasal branches* pass to the nasal cavity, one branch, the *nasopalatine nerve*, running to the anterior palatine or incisive canal. The *palatine nerves* pass through the pterygopalatine canal to the oral cavity, where they break up into the *anterior*, *middle*, and *posterior palatine nerves*. They supply the mucous membrane of the palate with sensory, and the muscles of the soft palate, excepting the tensor palati muscle, with motor filaments (see Figs. 53, 55 and 57).

BRANCHES OF DISTRIBUTION OF THE MAXILLARY NERVE.—The *maxillary nerve* passes through the *infraorbital sulcus* and *canal* to the *infraorbital region* of the facial surface of the maxilla, giving off numerous branches in its course (see Figs. 53, 56 and 57). In passing through the infraorbital canal it gives off the *superior dental branches* at various intervals through the minute canals in the body of the maxilla (see Figs. 53, 54 and 57). These *middle* and *anterior superior dental branches* supply the alveolar process, sending off small twigs to the teeth. Before entering the canal, the maxillary nerve gives off the *posterior-superior dental nerves* to the *maxillary tuberosity*, which partly follow the arteries, partly pass through their own foramina into the tuberosity (Figs. 53, 56 and 57) and the body of the maxilla. Following the arteries, they pass forward above the molars, branching out within the facial wall of the maxilla, and finally anastomose with the *middle* and *anterior-superior dental nerves*. They supply the oral mucosa, the molars, the mucous membrane of the maxillary sinus, the periosteum, and the pericementum (see Figs. 56 and 57).

The terminal portion of the maxillary nerve, or *infraorbital branch*, frequently divides into from two to four branches which arise closely together from the infraorbital foramen (see Fig. 56). They run in a curve from behind and above downward to forward and inward. Their numerous subdivisions form a thick nerve plexus, which in turn sends off finer branches to the oral mucosa, the floor of the nasal cavity, the incisors and canines, and the spongiose substance (see Fig. 56).

FIG. 54

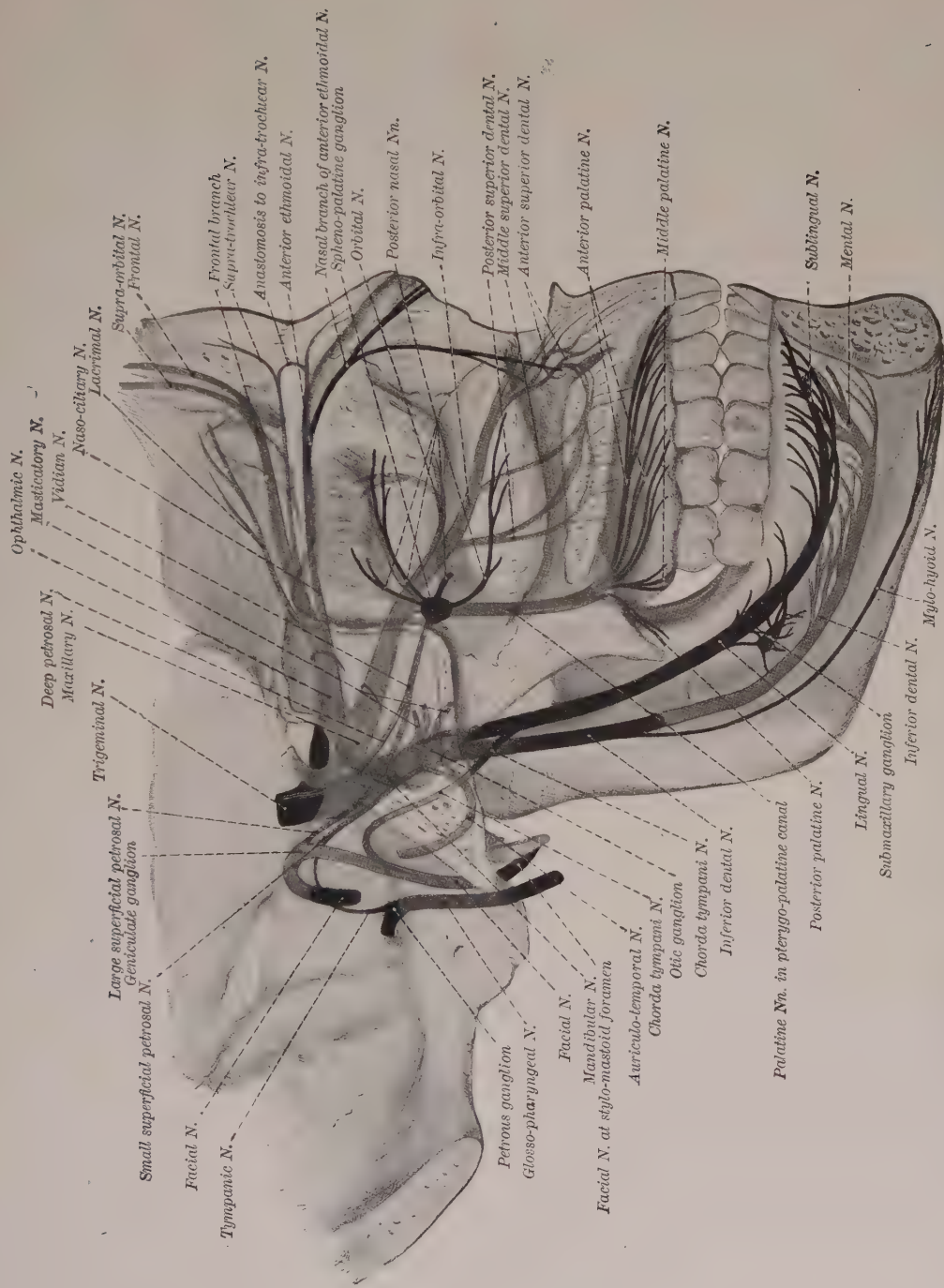


Diagram showing distribution of the fifth or trigeminal nerve. The black lines indicate the branches embedded in soft tissues, the gray lines those embedded in bony tissue. (After Sobotta.)

**The Mandibular Nerve.**—The third or mandibular division of the trigeminus makes its exit from the skull through the foramen ovale, dividing into a *superior*, chiefly *motor root*, and an *inferior*, chiefly *sensory root*.

From the superior motor root the masticatory muscles are supplied by the following branches: The *masseteric*, the *internal* and *external pterygoid*, and the *deep temporal branches*. The *buccinator nerve* is the only sensory branch, and supplies the mucous membrane of the cheek.

From the inferior root, the *inferior dental*, the *lingual*, and the *auriculotemporal branches* are given off (see Figs. 54 and 55).

The *inferior dental nerve*, before passing into the mandibular or inferior dental canal, gives off a motor branch, the *mylohyoid nerve*, and through the mental foramen a sensory branch, the *mental nerve* (see Figs. 54, 55 and 58).

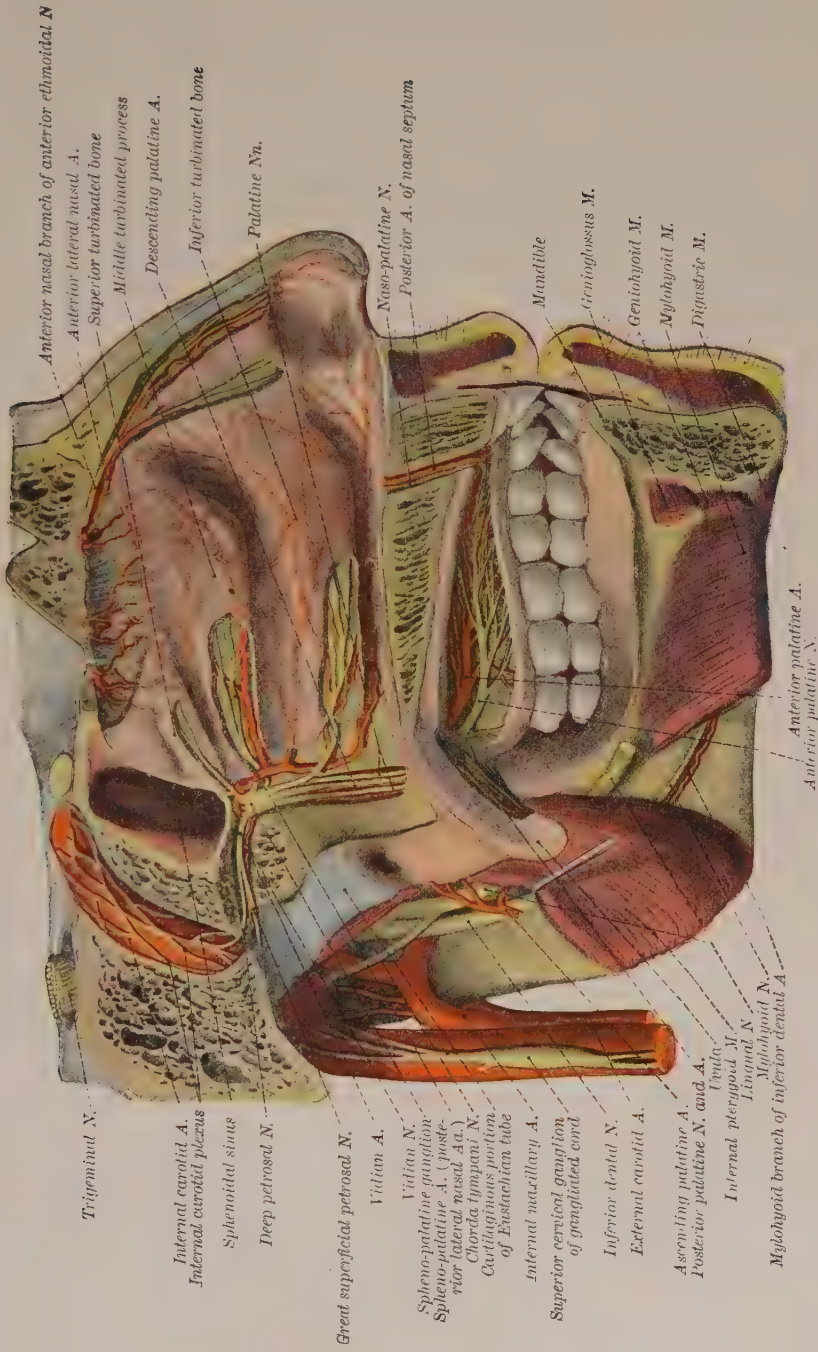
The *lingual nerve* supplies the tongue and the floor of the oral cavity with sensory filaments (see Fig. 59). From the *chorda tympani nerve*, which is a branch of the *facial nerve* (the seventh cranial), it receives secretory filaments which it conveys to the large mandibular glands. The chorda tympani nerve receives fibers from the glossopharyngeal nerve (the ninth), by anastomosis of the facial with the glossopharyngeal nerve.

To the third division of the trigeminus belongs also the *otic ganglion* (see Fig. 54), which is situated immediately below the foramen ovale. The *small superficial petrosal nerve*, a continuation of the *tympanic plexus*, conveys secretory and sympathetic filaments to the ganglion. The secretory filaments come from the glossopharyngeal, the sympathetic ones from the sympathetic plexus of the *internal carotid artery*, whence, through the *carotico-tympanic branches*, they communicate in the tympanic cavity with the *small superficial petrosal nerve*.

The motor root of the ganglion is derived from the smaller motor root of the trigeminus through filaments from the *internal pterygoid nerve*.

The otic ganglion also sends *motor* filaments to the *tensor palati* and the *tensor tympani muscles*, *secretory* filaments to the *parotid gland*.

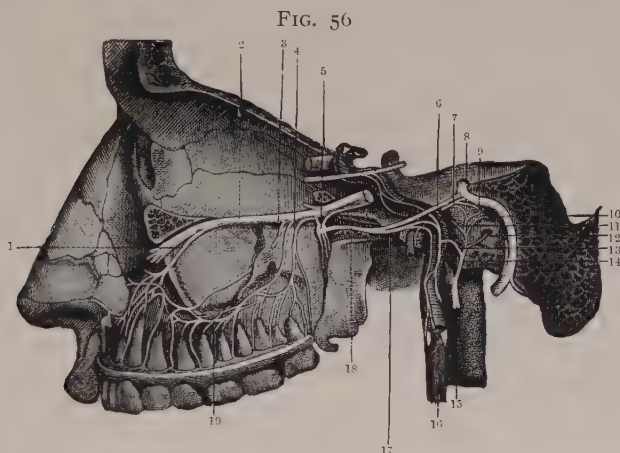
FIG. 55



The palatal and lingual nerves and vessels of the maxillary apparatus. Internal aspect. (After Sobotta.)



The main trunk of the *third division* of the trigeminal is the *mandibular* or *inferior dental nerve*. After giving off the mylohyoid branch it enters the long mandibular or inferior dental canal (see Figs. 55 and 58), passing along with the artery and the venous plexus below the roots of the molars (see Figs. 54 and 55). Before its entrance into the canal it gives off a few delicate twigs to the oral mucosa and the periosteum; within the canal it is frequently subdivided into several parallel

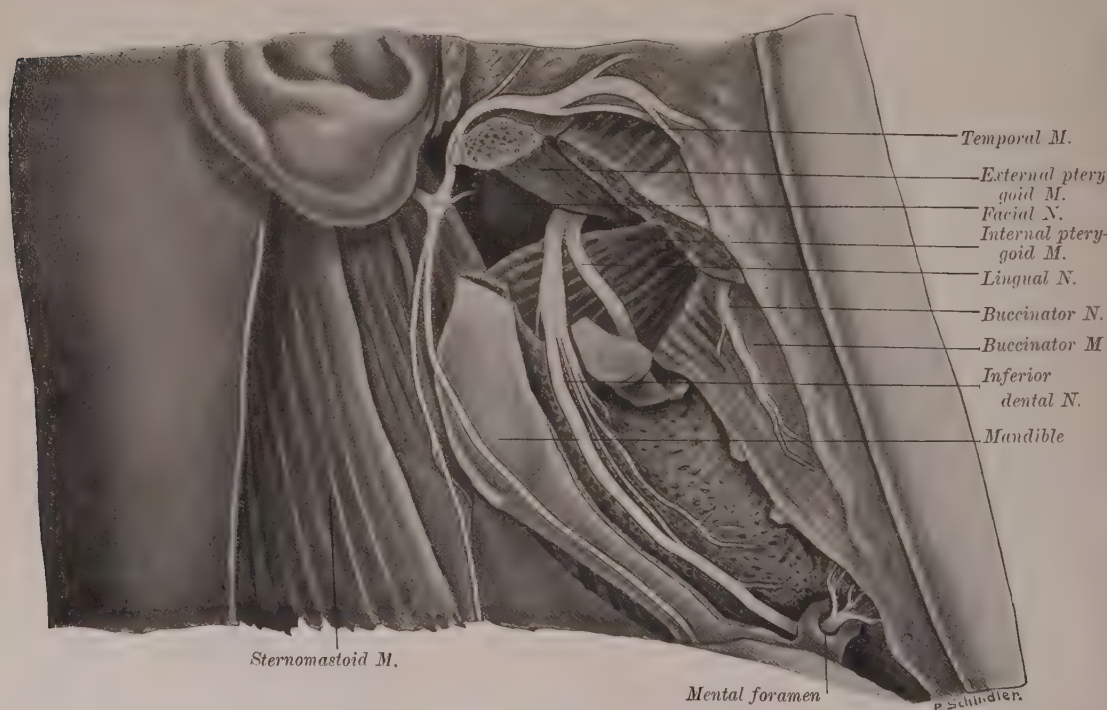


Distribution of superior maxillary nerve. (Hirschfeld and Leveillé.) The outer wall of the left orbit is removed, also most of the soft tissues in the vicinity of the maxilla. (From Rauber and Kopsch). 1, Anterior-superior dental branch; 2, infraorbital nerve; 3, middle-superior dental branches; 4, posterior-superior dental branches; 5, sphenopalatine ganglion; 6, large superficial petrosal nerve; 7, small superficial petrosal nerve; 8, facial nerve; 9, tympanic nerve; 10, branch to fenestra vestibuli; 11, ramus tubæ; 12, branch to fenestra cochleæ; 13, inferior carotico-tympanic nerve; 14, tympanic nerve; 15, glossopharyngeal nerve; 16, superior cervical ganglion of the sympathetic nerve; 17, deep petrosal nerve; 18, Vidian nerve; 19, superior dental plexus.

branches (see Fig. 56). One of these extends as far as the central incisors, where it anastomoses with the nerves of the other side. At the mental foramen it gives off the *mental branch* which supplies the anterior labial surface of the mandible, the mucosa, and the lower lip (see Fig. 54). In its course the inferior dental nerve, in close relationship to the corresponding vessels, gives off two large separate branches, a *posterior branch* to the molars, and a *middle branch* between the mandibular and the mental foramina to the bicuspid.

In front of the inferior dental nerve (see Figs. 54 and 55), the *lingual nerve* passes to the tongue, sending off on its way a side branch which is minutely broken up in the anterior portion of the mandible. In the bicuspid region it ascends, finely distributing itself in the periosteum as far as the genial tubercles.

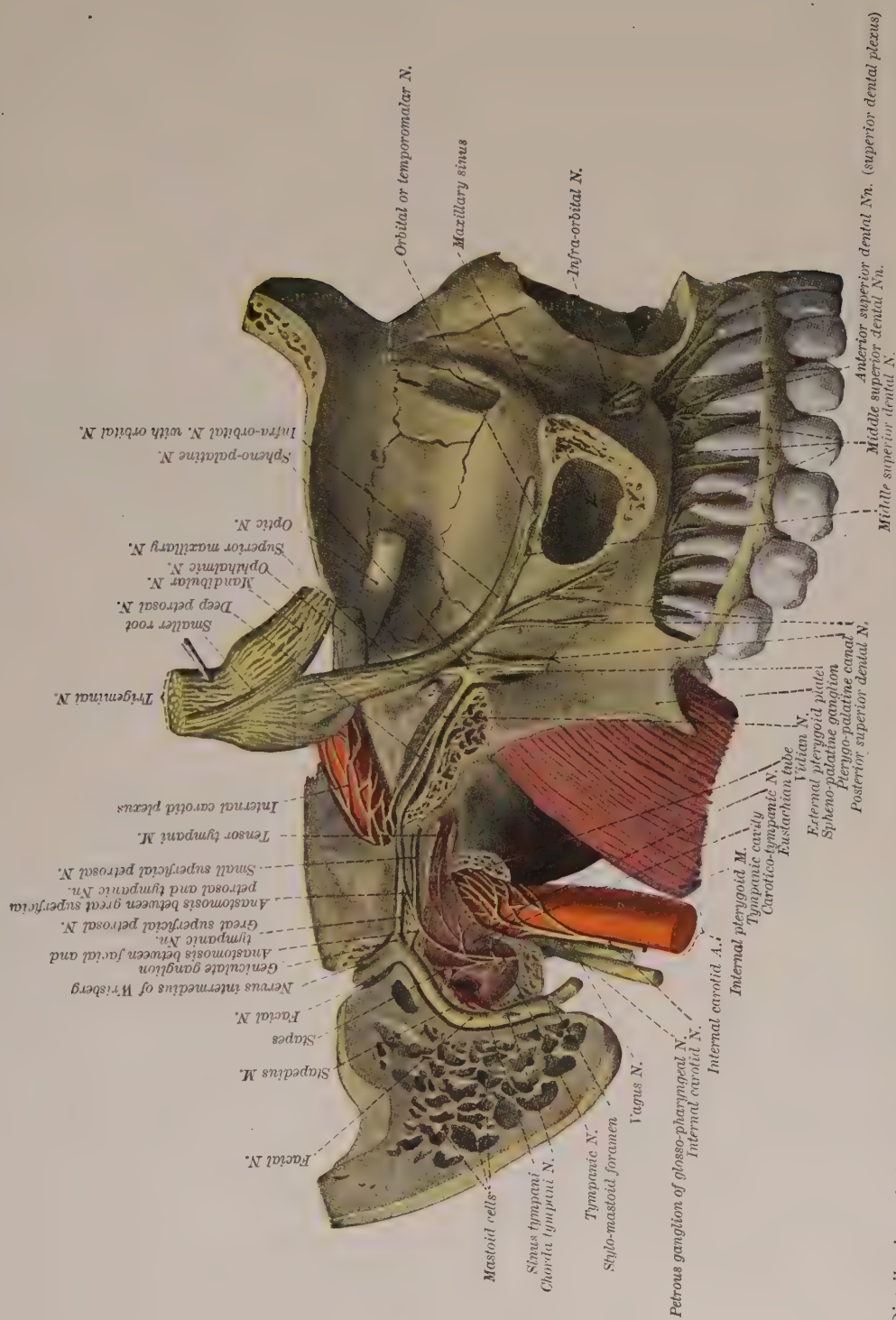
FIG. 58



Inferior dental or mandibular nerve. The strata of bone covering the nerve have been removed.  
(Original specimen by Gasser, of Marburg Anatomical Institute.)

**Anastomoses.**—Bünthe and Moral have emphasized, more strongly than this has been done before, the anastomoses within the trigeminal area, which are of greatest importance in dentistry. These investigators use the fitting term “nerve loops” for the intercommunication of some of the branches of the trigeminal nerve, the most important of which are the following: the inner nerve loop is formed by the *ante-*

FIG. 57

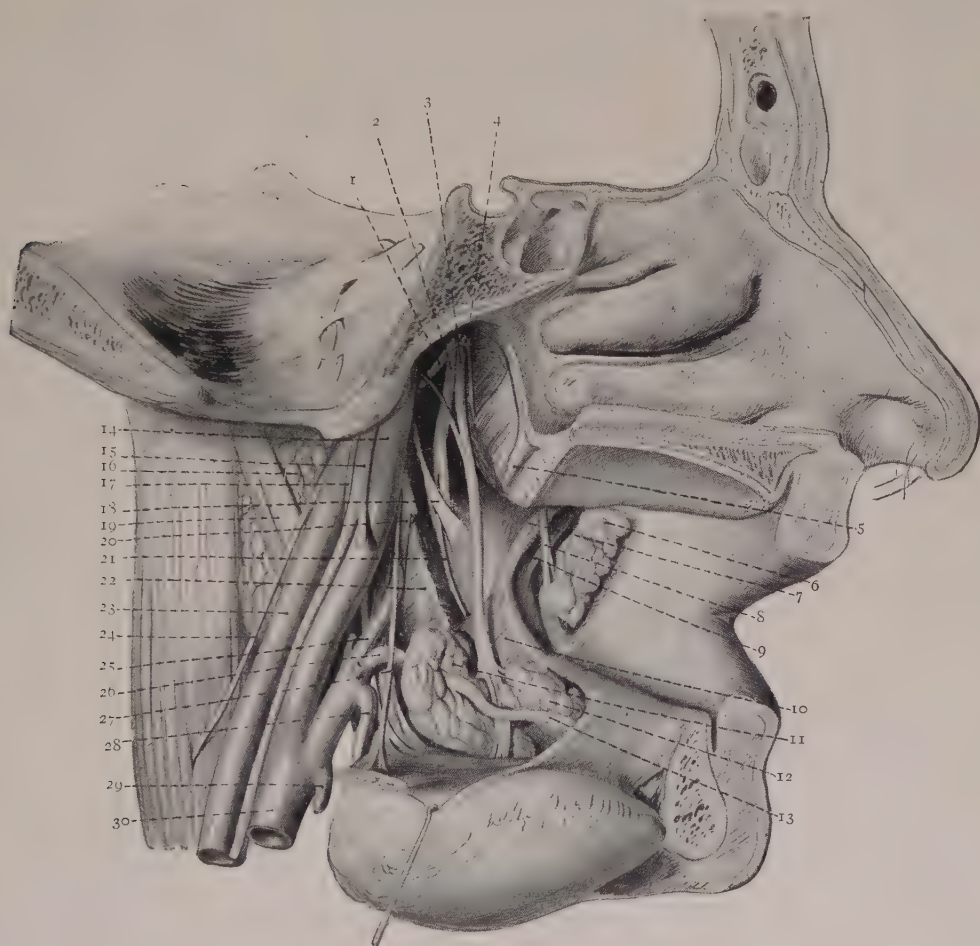


Distribution of the superior maxillary nerve (second division of trigeminal nerve), and course of the anterior, posterior, and middle superior dental nerves. (After Sobotta.)



*rior palatine nerve* (second division) communicating in the anterior palatine canal with the *nasopalatine nerve* (second division) (see Figs.

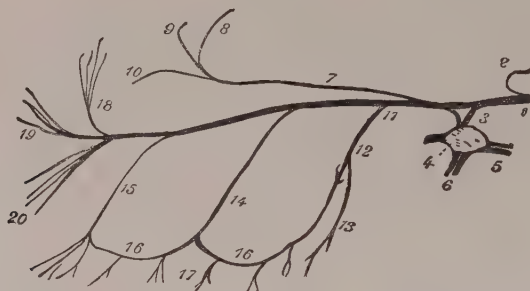
FIG. 59



Distribution of the mandibular division of the trigeminal nerve. (Sicher.) 1, Auriculo-temporal nerve; 2, mandibular ganglion; 3, lingual nerve; 4, otic ganglion; 5, pterygoid hamulus; 6, adipose tissue; 7, deep portion of temporal muscle; 8, buccinator nerve; 9, superficial portion of temporal muscle; 10, mylohyoid muscle; 11, submaxillary gland; 12, sublingual gland; 13, submaxillary duct; 14, internal carotid artery; 15, vagus nerve; 16, parotid gland; 17, hypoglossal nerve; 18, sphenomandibular ligament; 19, digastric muscle; 20, stylomandibular ligament; 21, mylohyoid nerve; 22, internal pterygoid muscle; 23, internal jugular vein; 24, accessory nerve; 25, external carotid artery; 26, external maxillary artery; 27, glossopharyngeal nerve; 28, lingual artery; 29, superior thyroid artery; 30, common carotid artery.

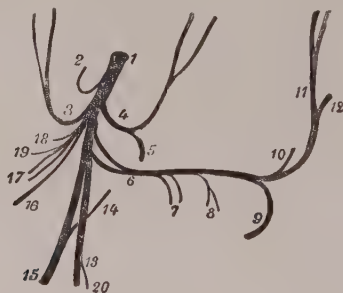
54 and 55). On the anterior surface of the maxilla the *posterior, middle, and anterior-superior dental nerves* form the outer nerve loop anastomosis-

FIG. 60



Distribution of maxillary nerve. (Raubert-Kopsch.) 1, Trunk of maxillary nerve; 2, meningeal branch; 3, sphenopalatine branches; 4, sphenopalatine ganglion; 5, Vidian nerve; 6, palatine branches; 7, zygomatic nerve; 8, branch anastomosing with zygomatic nerve from lacrimal branch of ophthalmic nerve; 9, zygomatico-temporal nerve; 10, zygomatico-facial nerve; 11, infraorbital nerve; 12, 13, posterior-superior alveolar nerves; 14, middle-superior alveolar nerves; 15, anterior-superior alveolar nerves; 16, superior dental plexus; 17, superior dental and gingival branches; 18, inferior palpebral nerves; 19, external nasal nerves; 20, superior labial branches of infraorbital nerve.

FIG. 61



Distribution of mandibular nerve. (Raubert-Kopsch.) 1, Mandibular nerve; 2, spinous nerve; 3, anterior deep temporal nerve; 4, posterior deep temporal nerve; 5, masseteric nerve; 6, auriculo-temporal nerve; 7, articular branches; 8, parotid branches; 9, branch anastomosing with facial nerve; 10, external auditory meatus nerve; 11, superficial temporal branches; 12, anterior auricular nerve; 13, inferior alveolar nerve; 14, chorda tympani; 15, lingual nerve; 16, long buccal nerve; 17, internal and external pterygoid nerves; 18, tympanic nerve; 19, tensor veli palatini nerve; 20, mylohyoid nerve.

ing with one another and with the infraorbital nerve (see Figs. 53 and 57), as do the *infraorbital nerves* in the median line at the nasal spine. In the mandible, the *inferior dental nerves* of each side communicate

with one another at the symphysis. Numerous terminal loops of the second and third divisions, which supply the alveolar processes, are distributed in the oral mucosa as the gingival *posterior* and *anterior-superior alveolar* or *gingival nerves*, and the *large* and *small palatine nerves*.

**Stimuli Referred by Anastomoses.**—The nerves supplying the individual teeth are really nerve terminals which communicate with the central nervous system by larger tracts of supply. Since they stand also in direct relationship to neighboring areas, it is easily understood why pathological conditions in teeth very frequently involve neighboring normal pulps. It is not surprising, then, that especially in dental disorders the pain is so extraordinarily intense, frequently affecting large neighboring areas. By anastomoses with the *opposite side*, sensations are often referred thereto. Owing to the relations of the trigeminal nerve to the *facial nerve*, pain in diseases of the *lower teeth* is often referred to the *ear* by way of the tympanic branch, as the mandibular nerve communicates through the *auriculo-temporal nerve* with the nerves of the external auditory meatus, whence the tympanic branch passes to the tympanic membrane. In the *maxilla* we frequently observe radiation of pain from the alveolar process to the temporal region, the eyes, the forehead, the neck, or even the upper arm. The same relationships are noted in anesthesia.

Strong electric currents applied to the teeth or the oral mucosa disclose certain very interesting relationships between the different areas of nerve supply in the facial portion of the skull. *Scintillations in the eye* and an *increase in the lacrimal secretion*, for instance, can be produced by applying strong electric currents to *all the teeth*, both upper and lower; that is, by stimulation of the second and third divisions of the trigeminal nerve. Stimulation of the soft palate is usually followed by an increase in lacrimal secretion only. These relationships are of the greatest importance in regard to pathology, as serious disorders of the teeth may involve the organs supplied by the *second trigeminal branch*.

The diagram in Fig. 54 clearly illustrates the intimate relations existing between the trigeminal nerve and the branches of other cranial nerves within its area of distribution.

## AREAS OF NERVE SUPPLY OF THE MASTICATORY APPARATUS.

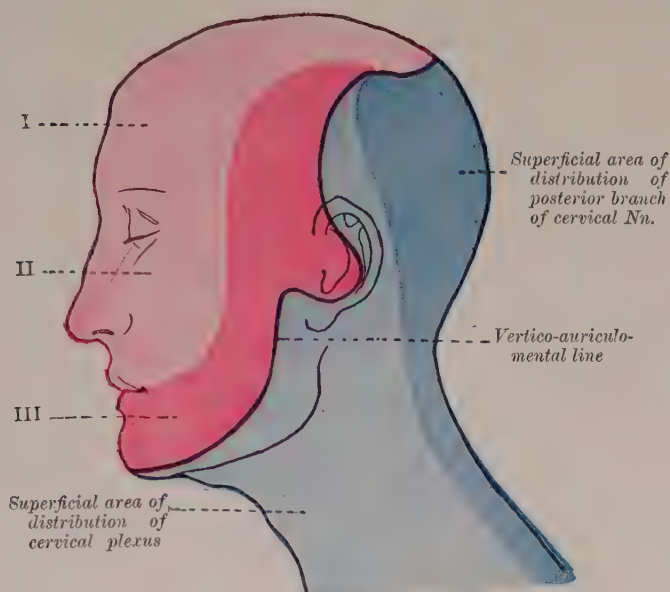
In order to offer a clear picture of the distribution of the individual nerve trunks in the masticatory apparatus, a thorough knowledge of which is of paramount importance in local anesthesia, the different areas of nerve supply are represented in colored diagrams (see Figs. 62 to 66). In the head we distinguish generally three definite nerve areas, as illustrated in Fig. 62.

**Maxilla.**—Looking at the anterior surface of the skull, we note in the *maxilla* three such areas (see Fig. 63). The upper incisors and canines belong to the *blue* area supplied by the *anterior-superior dental nerves*; the molars to the *yellow* area supplied by the *posterior-superior dental nerves*, while the bicuspid, in the *green* area, stand in relationship to both sides. The blue and yellow areas represent portions that are supplied by one single nerve branch each, while the green areas are of mixed character. The nerve supply of these green areas is furnished by three branches, viz.: the *middle-superior dental nerve* proper which supplies the bicuspid, and the anterior- and posterior-superior dental nerves on either side which anastomose with the middle branch (see Fig. 53).

In the green and blue areas, the nerves run partly behind the facial plate of the alveolar process, partly below the mucous membrane of the maxillary sinus (see Figs. 53 and 57). In some portions, this plate, as we have seen, is of spongiöse character, and renders it most favorable for the diffusion of anesthetic solutions. At the *maxillary tuberosity* several branches of the *posterior-superior dental nerves* penetrate the facial wall (see Figs. 53, 56 and 57) and can here be reached by the hypodermic needle.

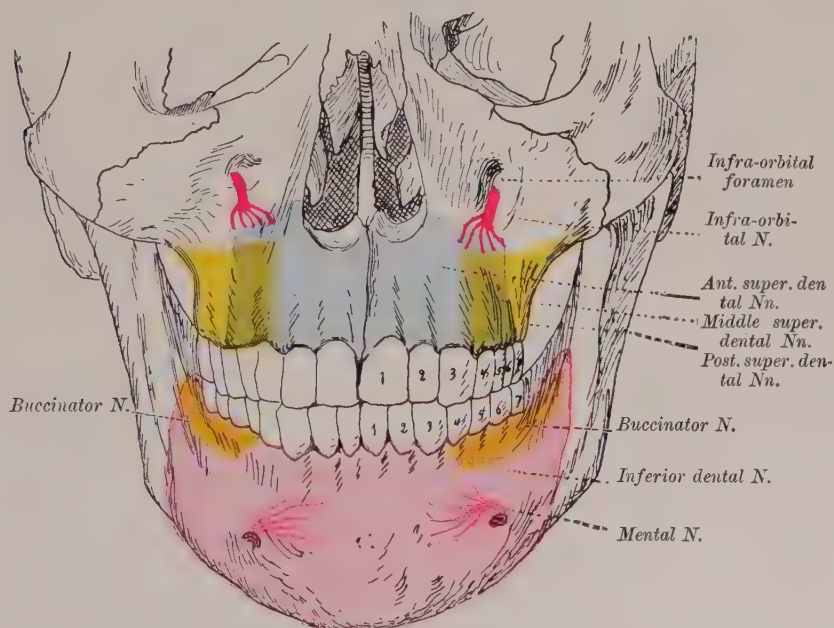
The *palatal surface of the maxilla* may be divided into an *anterior blue* and a *posterior red* section. The latter is supplied by the *anterior palatine nerve* (see Fig. 65) which emerges upon the hard palate by way of the posterior palatine foramen above the third molar (see Figs. 55 and 56), and, passing forward and toward the median line, communi-

FIG. 62



Distribution of trigeminal nerve. I, II, III divisions of trigeminal nerve. (After Toldt.)

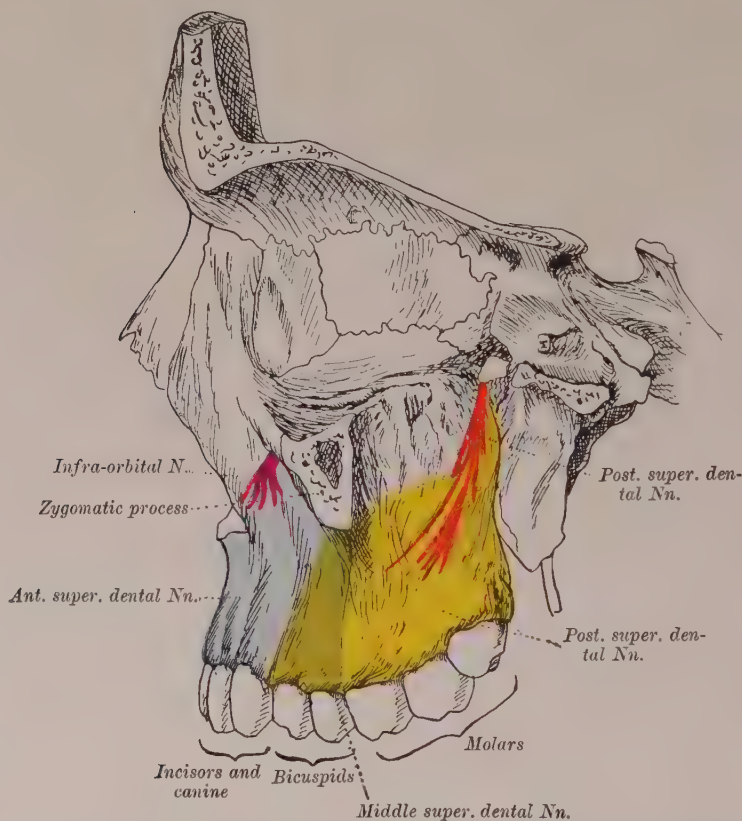
FIG. 63



Areas of nerve supply of maxillary apparatus. Front view. Red area: inferior dental nerve. Yellow area: posterior-superior dental nerves. Green area: Middle-superior dental nerves. Blue area: anterior-superior dental nerves.

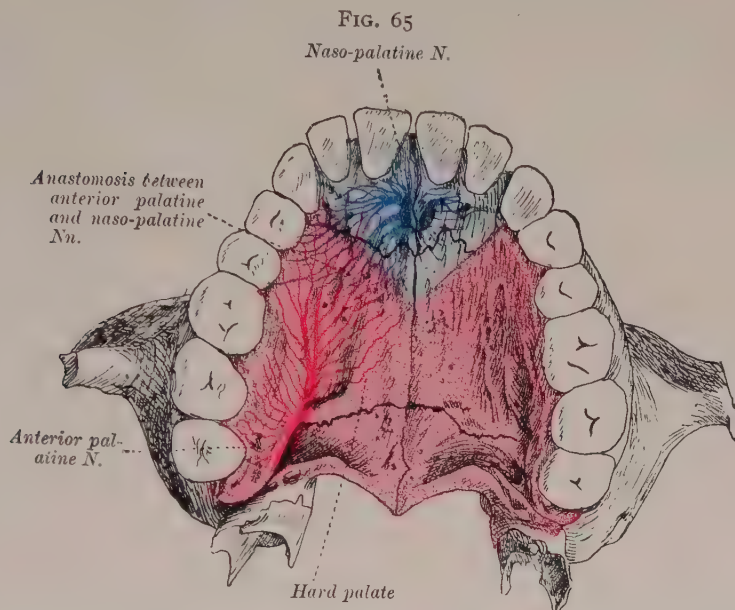
cates in front with the *nasopalatine nerve* (see Fig. 55). The filaments of the latter supply the area at the *anterior teeth* as far as the bicuspid.

FIG. 64

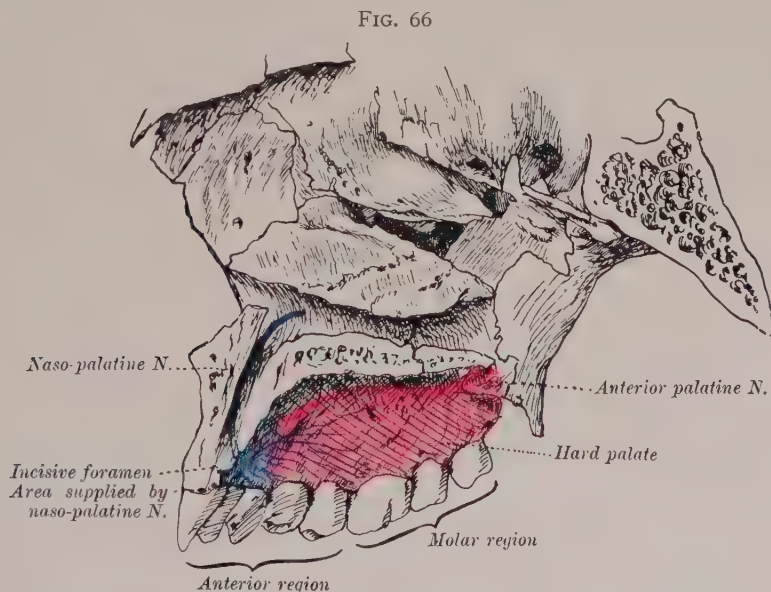


Areas of nerve supply of maxilla. Blue area: anterior-superior dental nerves (incisor and canine region). Green area: middle-superior dental nerves (bicuspid region). Yellow area: posterior-superior dental nerves (molar region).

**Mandible.**—The nerve supply of the *mandible* is dominated entirely by the *mandibular*, or *inferior dental nerve*, which passes through the mandibular canal (see Fig. 54). The *red* area, which marks its distribution, is interrupted only in its posterior or molar portion by an *orange-yellow* area indicating sensory fibers of the *buccinator nerve*, which supplies the buccal mucosa of the molars and bicuspid (see

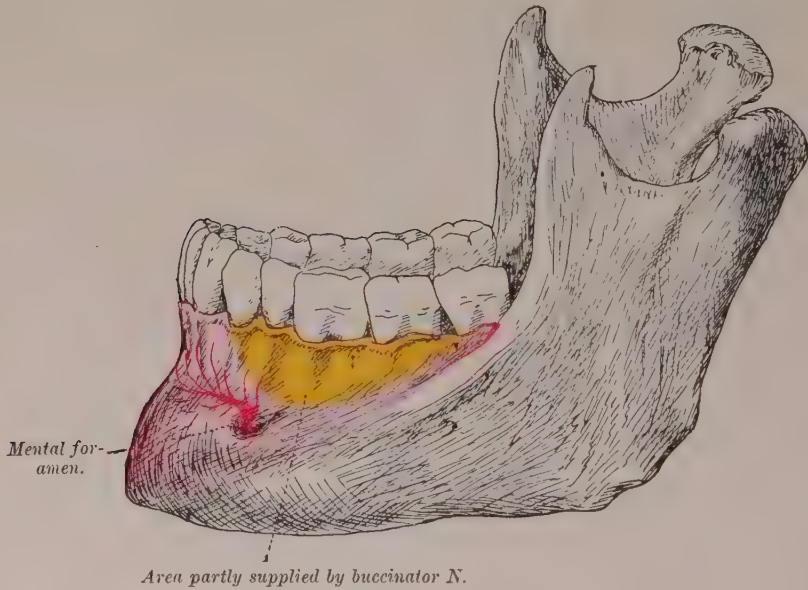


Areas of nerve supply of palatal surface of maxilla. Blue area: nasopalatine nerve. Red area: anterior palatine nerve (molar region).



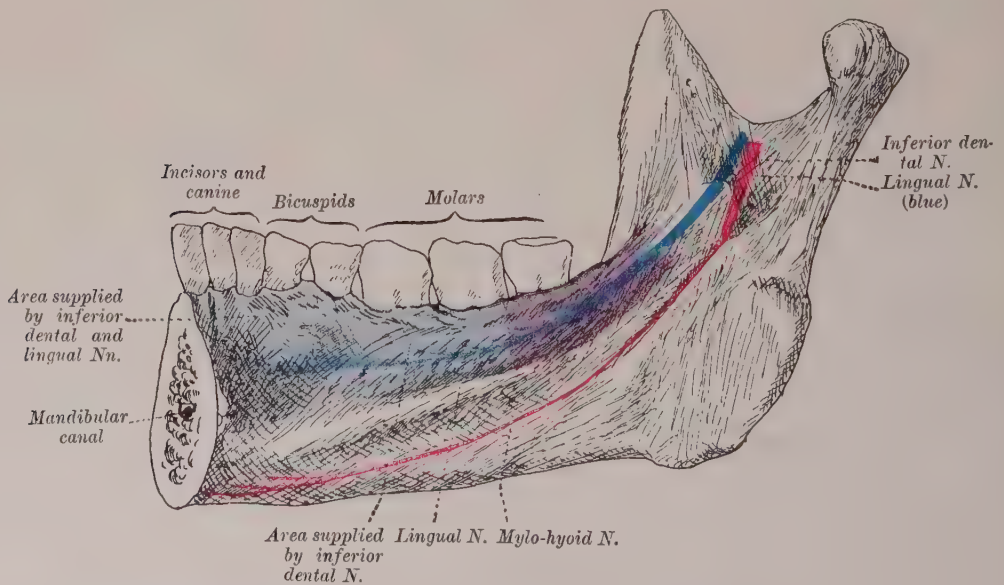
Areas of nerve supply of palatal surface of maxilla. Red area: anterior palatine nerve (molar region). Blue area: nasopalatine nerve (incisor and canine region).

FIG. 67



Areas of nerve supply of anterior portion of mandible. Red area: inferior dental nerve. From the mental foramen emerges the mental nerve. The mucous membrane in the molar and bicuspid region (yellow) is partly supplied by sensory fibers of the buccinator nerve.

FIG. 68



Areas of nerve supply of lingual portion of mandible. Red area: inferior dental nerve. The mylo-hyoid nerve branches off at the inferior dental foramen. Blue area: lingual nerve.

Figs. 67 and 68). Before entering the canal, the mandibular nerve also gives off some delicate sensory filaments to the mandibular mucosa (see Fig. 58).

The lingual surface of the mandible is supplied by the *lingual* nerve, the latter is a large branch descending in front and mesially of the inferior dental nerve; it gives off numerous branches to the lingual mucosa as far as the incisors. Some of its terminal filaments in the vicinity of the genial tubercles probably extend through foramina to the anterior portion of the mandibular canal (see Fig. 39).

Regarding these nerve zones in the maxillæ, Scharlau has published some observations based upon the behavior of the mucosa following the various injections; his results, therefore, seem to be slightly at variance with our own. The nerve zones indicated above are drawn from anatomic specimens, hence correspond to the distribution of the individual nerve branches, while Scharlau simply tested for sensibility following injection.

The area innervated by the *nasopalatine* or *incisive nerve* extends only to the canines; the rest of the hard palate is innervated by the *anterior palatine nerve*. Injection at the *maxillary tuberosity* fully anesthetizes only the molars, but not the second bicuspid, although occasionally the buccal mucosa is rendered insensible in the bicuspid region.

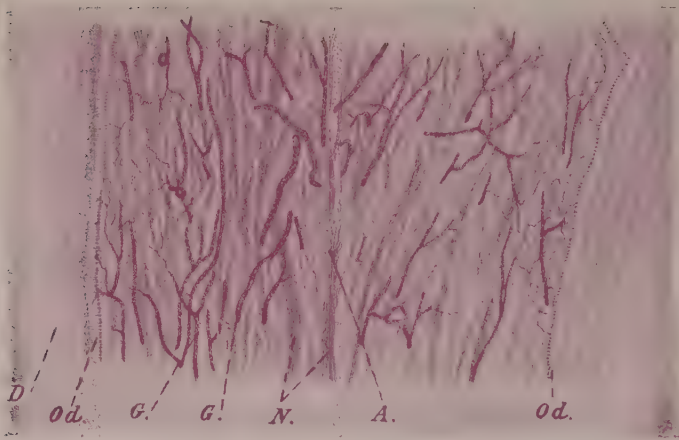
Injection at the *infraorbital foramen* never produces anesthesia of the first molar, though its overlying mucosa may be rendered insensible. Infraorbital injection anesthetizes chiefly the incisors and canine, sometimes the bicuspid.

The *bicuspid*s are most satisfactorily anesthetized by depositing some solution in the canine fossa, inserting the needle in the line of reflection of the mucosa above and between first and second bicuspid.

Injection of the *buccinator* or *long buccal nerve* in the line of reflection in the first molar region is indicated for surgical work. The zone innervated by the buccinator nerve varies in extent; it usually reaches from the second molar to the second bicuspid, sometimes even as far as the canine.

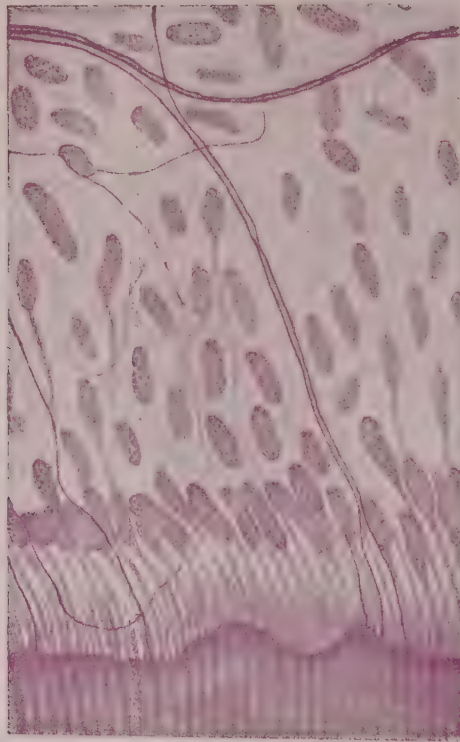
The mucosa of the third molar region is supplied by the inferior

FIG. 69



Nerves and bloodvessels in the pulp.  $\times 56$ . *D*, dentin; *Od*, odontoblasts; *G*, bloodvessels; *N*, nerves; *A*, ramusculi of nerve fibers.

FIG. 70



Nerve fibers running between the odontoblasts to the dentin. (Fritsch.)

dental nerve which, before entering the mandibular canal gives off several fine filaments (see Fig. 68). Accordingly, the area supplied exclusively by the *lingual nerve* commences at the second molar and continues to the genial tubercles.

Within the alveolar processes the nerve trunks are distributed most minutely. The *periosteum* as well as the *pericementum* are especially richly endowed with sensory filaments.

The nerves of the dental pulp consist of sensory fibers of the trigeminal nerve and enter the pulp in one or several stout bundles or trunks by way of the apical foramen together with the bloodvessels. About the middle portion of the pulp canal these trunks branch out considerably, so that in incisors, for instance, from thirty to forty bundles can be counted. These bundles consist of cylindrical strands composed of medullated nerve fibrils of from 6 to 10 microns in diameter. Each bundle is surrounded by a sheath of connective tissue resembling the perineurium. The fibrils in these bundles run in the direction of the long axis of the tooth, and can clearly be traced to the internal terminal lamina of the dentin (see Fig. 70).

**Sensitivity of the Dentin.**—In the *odontoblastic layer* the most delicate tendrils of the nerve filaments are distributed, arborizing around the odontoblasts, together with a graceful network of lymphatic capillaries. In the same area we find a capillary network. As the odontoblasts with their cell processes control the nutrition of the dentin which forms the bulk of the tooth, their relationship to the nervous and lymphatic systems is easily understood.

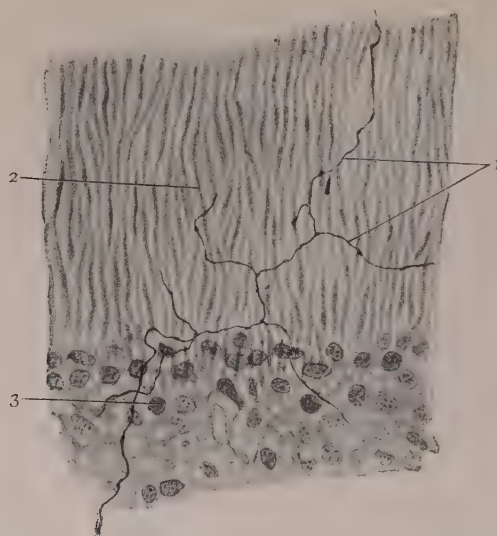
Dependorf has proved that the nerve fibrils penetrate the dentin by two routes, viz., within the basic substance as well as within the dentinal tubuli. This double distribution of nerves within the dentin suggests the assumption that part of these nerve fibrils serves the purpose of sensation, part that of nutrition and metabolism.

Nerve terminals are demonstrable in the pulp as well as within the odontoblastic layer and within the dentin at the junction of enamel and cementum.

For practical dental anesthesia we may follow the rule that with the exception of the enamel of the teeth, all the tissues of the oral cavity

possess great sensibility, while special organs such as the pulp, the pericementum and the periosteum are endowed with a specially marked degree of irritability, which can be abolished only by close attention to the somewhat exacting technique of injection.

FIG. 71



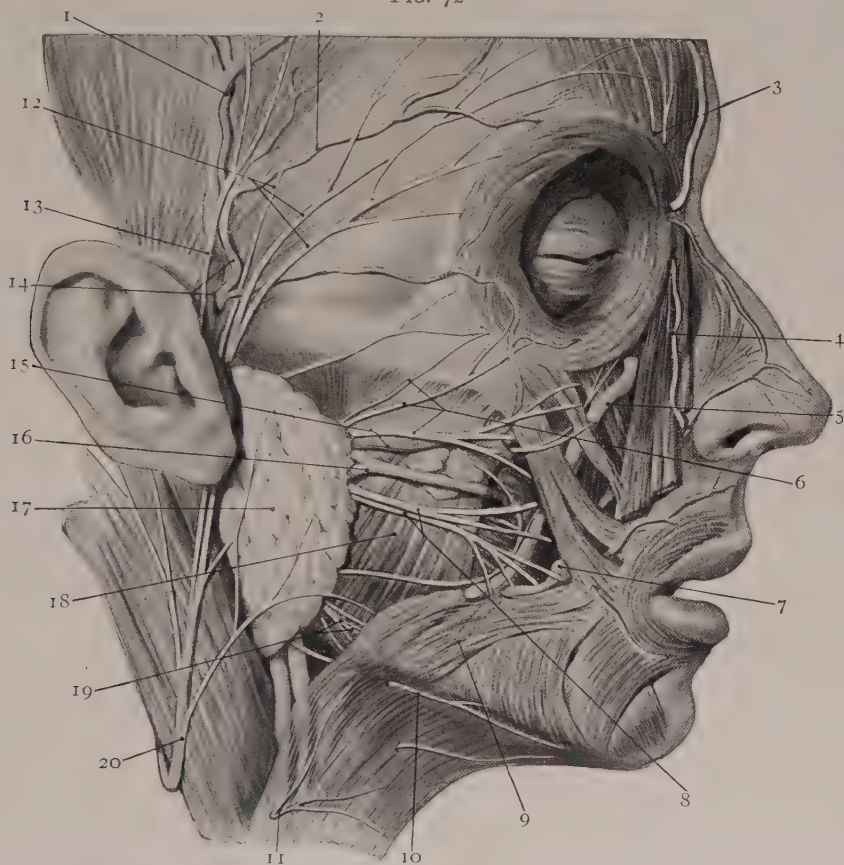
Nerve fibers in dentin. (Dependorf.) 1, Nerve fibers; 2, dentin; 3, odontoblasts.

### THE BLOOD SUPPLY OF THE MASTICATORY APPARATUS.

The blood supply of the maxillæ is an important factor in local anesthesia, especially in regard to the introduction of the needle. Maxilla and mandible with their soft tissue covering are supplied chiefly by two main vessels, the *internal maxillary artery* and the *external maxillary artery*. For *extra-oral injections*, the nerves, arteries and veins of the face must be given special attention. Figs. 72 and 73 present a general view of the distribution of the bloodvessels and nerves in question. We observe, first of all, the various groups of facial muscles which are pierced by the needle, especially in injection anterior to the tragus and below the zygomatic arch for the purpose of blocking the second division of the trigeminal nerve in the sphenomaxillary fossa. In cases

of extra-oral injection at the infraorbital foramen, the distribution of the angular artery and the anterior facial vein with their ramifications command attention (see Fig. 73).

FIG. 72

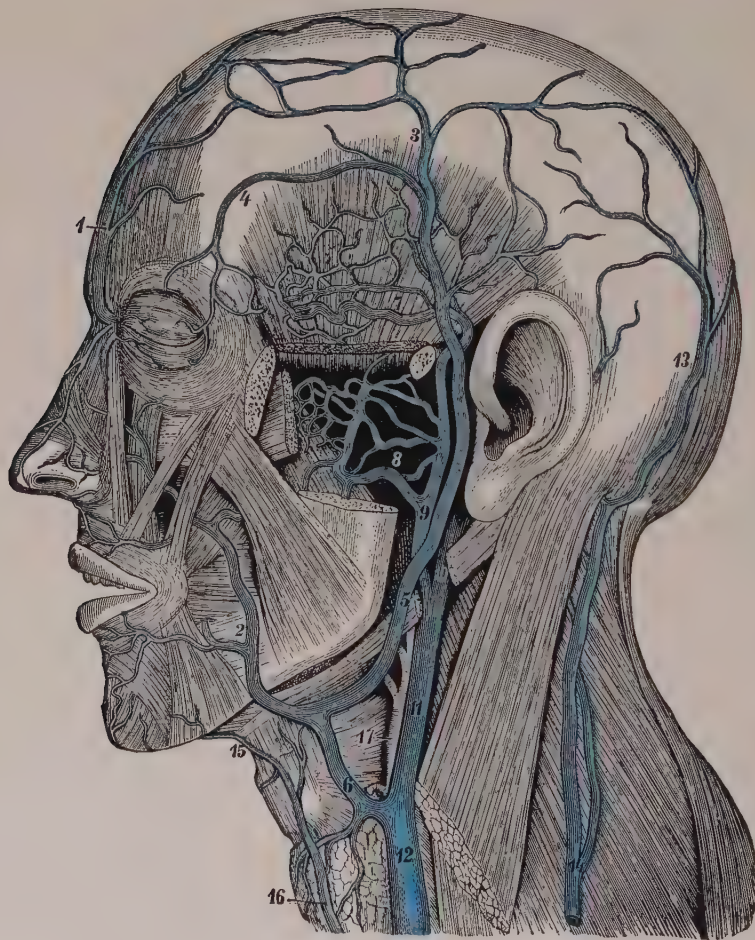


Topography of cheek and face. Lateral veins. (After Corning.) 1, Parietal branch of superficial temporal artery; 2, frontal branch of superficial temporal artery; 3, supraorbital nerve; 4, angular artery; 5, anterior facial vein; 6, middle facial nerve branches; 7, external maxillary artery; 8, middle facial nerve branches; 9, external maxillary artery; 10, marginal branch of facial nerve; 11, middle cutaneous colli nerve; 12, superior facial nerve branches; 13, auriculo-temporal nerve; 14, superficial temporal artery and vein; 15, transverse facial artery; 16, parotid duct; 17, parotid gland; 18, masseter muscle; 19, inferior facial nerve branches; 20, great auricular nerve.

Closely in front of the external ear we note the large temporal artery and vein and the auriculo-temporal nerve, a branch of the man-

dibular nerve, ascending from the angle of the mandible to the temporal region. Below the ear and behind the parotid gland, the *facial nerve* (motor) radiates over the cheek.

FIG. 73



Superficial veins of head. (Raubert-Kopsch.) The zygomatic arch and superior portion of maxilla; the temporal and external pterygoid muscles and posterior portion of the masseter muscle have been resected, and the digastric muscle divided. 1, Frontal vein; 2, anterior facial vein with labial vein; 3, superficial temporal vein; 4, frontal branch; 5, posterior facial vein; 6, common facial vein; 7, middle and deep temporal veins; 8, pterygoid plexus; 9, internal maxillary vein communicating with posterior facial vein and internal jugular vein; 10, 11, 12, internal jugular vein; 13, occipital vein; 14, external jugular vein; 15, submental vein; 16, median colli vein; 17, external carotid artery.

By dissecting away the muscles and the anterior bony layers of the jaws, we gain an insight into the distribution of the *external* and *internal maxillary arteries* and their relationship to the mandibular division of the trigeminal nerve.

The *external maxillary artery* arises from the *external carotid*, passes through the submaxillary triangle to the submaxillary gland and emerges at the anterior margin of the insertion of the masseter muscle upon the outer ramus of the mandible, where its pulsation is plainly felt. In a tortuous course it passes upward over the buccinator and canine muscle to the ala of the nose as the *angular artery*, where it anastomoses with the *arteria dorsalis nasi* which emanates from the orbit. Its lower portion anastomoses with the *buccinator* and *infra-orbital arteries* (from the internal maxillary artery). In its ascent over the face the external maxillary artery gives off at the mandibular border the *submental artery* to the anterior floor of the mouth.

Closely below the origin of the external maxillary artery, the important *lingual artery* arises from the external carotid, and shortly enters the tongue below the hyoglossus muscle, after giving off the *hyoid branch* to the hyoid bone.

After removing the parotid artery and a portion of the mandible, we note the deeper lateral aspect of the face, the area of distribution of the *internal maxillary artery*. Immediately after its origin from the external carotid artery, it passes behind the neck of the condyle of the mandible, thence to the external surface of the external pterygoid muscle, and terminates in the sphenopalatine fossa. We distinguish *three groups of vessels* branching from the internal maxillary artery (see Fig. 72).

*First or Maxillary part:*

1. *Deep auricular branch*, supplying the mandibular joint, tympanic membrane and external acoustic meatus.
2. *Tympanic branch*, supplying the tympanum.
3. *Inferior dental branch*, running to the mandibular canal, supplying the lower teeth, passing through the mental foramen as *mental artery*, thence to the chin together with the mental nerve.

4. *Middle meningeal branch*, the largest branch of the first group, passing over the internal pterygoid muscle and entering the skull through the foramen spinosum.

*Second or Pterygoid part:*

1. *Masseteric branch*, supplying the masseter muscle.
2. *Anterior and posterior deep temporal branches*, supplying the temporal region.
3. *Pterygoid branches*, supplying the pterygoid muscles.
4. *Buccal branch*, supplying the buccinator muscle.
5. *Posterior-superior alveolar branches*, passing through the maxillary sinus and supplying the upper molars.

*Third or Pterygopalatine part:*

1. *Infraorbital branch*, passing through the infraorbital canal to the anterior portion of cheek, giving off *anterior- and middle-superior alveolar branches* which supply incisors, cuspid and bicuspid.
2. *Descending palatine branch*, passing downward through the pterygopalatine canal, dividing into the *greater palatine branch*, which arises through the anterior palatine foramen upon the palatal surface, and the *lesser palatine branches*, which supply the soft palate.
3. *Pharyngeal branch*, supplying the pharynx.
4. *Sphenopalatine branch*, supplying the nasal cavity.

The *veins of the head* unite in the large *internal jugular vein* which leads to the superior vena cava (see Fig. 73). It collects the bulk of the blood from the interior of the cranium and from the superficial parts of the face. For our purposes, the following tributaries are to be noted.

1. *Pharyngeal veins* from the pharyngeal plexus.
2. *Lingual veins* from the dorsum, sides and under surface of the tongue; they receive the deep lingual, dorsal lingual and sublingual veins.
3. *Sternocleidomastoid vein* from the muscular area of that name.
4. *Superior thyroid veins*, from the thyroid gland.

5. *Common facial vein*, formed by the union of the anterior and posterior facial veins, and receiving the deep facial vein from the external aspect of the buccinator muscle.

The great *anterior* and *posterior facial veins* are the main venous channels of the masticatory apparatus.

The *anterior facial vein* commences as the *angular vein* from the confluence of the frontal, supraorbital and superior ophthalmic veins and passes obliquely over the side of the face to the anterior border of the masseter muscle; it lies behind and follows a less tortuous course than the external maxillary (facial) artery. At the lower border of the mandible it crosses beneath the angle over the capsule of the submaxillary gland and unites with the posterior facial (temporo-maxillary) vein to form the *common facial vein*.

The *posterior facial (temporo-maxillary) vein* runs downward from in front of the external ear toward the angle of the mandible, and receives the following tributaries: *superficial temporal, middle temporal, posterior parotid, articulares mandibulae, anterior auricular, transverse facial, stylo-mastoid* and *internal maxillary veins*.

The *internal maxillary vein* largely follows the course of the internal maxillary artery.

Three or four *deep temporal veins* run down from the temporal muscle, receiving the *pterygoid, masseteric, and buccinator veins* from the muscles of those names and forming the *pterygoid plexus* between the upper muscles of mastication. This plexus receives as further tributaries the *middle meningeal, maxillary* and *mandibular veins*. It consists further of an external, middle and internal division, all of which communicate with the cavernous sinus through the foramen lacerum medium and foramen ovale. For extra-oral injection, this plexus is of importance, owing to its extensive and dense network of bloodvessels situated in front of the external ear.

## THE TECHNIQUE OF INJECTION.

After the foregoing considerations, the technique of injection is merely a question of logical utilization of the factors described. The

peculiarities of the bony structures, as well as the nerve and blood supply, furnish us with definite guiding lines for a well-defined procedure of injection. Although some modifications have been suggested, the methods described in this book furnish, so far, the most reliable basis for successful and safe operations.

Anesthesia by local injection, as formerly employed in dental practice, was limited to *anesthesia of the mucous membrane*. In recent years *conduction anesthesia* was introduced, and with the adoption of this method in dentistry our results have become truly phenomenal.

FIG. 74



A

B

Types of innervation and nerve blocking. (Haertel.) A, Converging type (trigeminal area); B, diverging type (peripheral injection, as in mucous anesthesia and in abscessed areas). White, sensory nerves; black circle, field of operation.

Conduction anesthesia in the mandible, for example, is really the first and only method to guarantee complete and safe anesthesia of that region.

Conduction anesthesia as employed in dental practice represents *perineural injection* by which the solution is deposited in closest vicinity of the nerve trunk. The effect of the anesthetic is an immediate one, and occurs the more rapidly and intensely the finer are the nerve fibers inundated with solution. The farther away from the terminal distribution of a nerve we inject, the more difficult will be the blocking, the

slower the establishment of insensibility, the greater the quantity and the concentration of the anesthetic required.

Every infiltration of a tissue area which contains afferent nerves produces not only infiltration anesthesia in the infiltrated area, but also conduction anesthesia in the zone of distribution of the nerves involved. From this it follows that in dental anesthetics we always induce a perineural anesthesia, strictly speaking, regardless of whether we block the mandibular nerve in the mandibular sulcus or infiltrate the mucosa and periosteum at the alveolar process. Theoretically, infiltration and conduction anesthetics are entirely different methods, for practical purposes they cannot be separated and must therefore be discussed together. We no longer induce inundation of the tissues layer by layer in the prospective line of incision after the Reclus-Schleich method, but we aim to render the entire field of operation insensible by infiltration of certain tissue areas alone or in combination with the blocking of individual nerve trunks. Practically, therefore, we use the immediate result of tissue infiltration, infiltration anesthesia, in rare cases only; rather are we profiting from the conduction anesthesia which results automatically from tissue infiltration.

Consequently, we shall discuss

1. *Infiltration or mucous anesthesia*, which is also termed *terminal, subcutaneous, submucous, peripheral or plexus anesthesia*.
2. *Intra-oral conduction anesthesia, trunk anesthesia or nerve blocking*.
3. *Extra-oral conduction anesthesia*.

Infiltration anesthesia blocks innervation within the field of operation, conduction anesthesia at the place of choice.

### INFILTRATION ANESTHESIA.

By *infiltration anesthesia* we mean anesthesia of a circumscribed portion of the jaw induced by way of the oral mucosa. The course of this anesthesia varies according to the condition of the mucous membrane, the manner of insertion of the needle, and the pressure under which the solution is injected into the tissues. By infiltrating a tissue

area with an anesthetic solution, the functions of the nerves supplying that area are paralyzed.

The *mucosa* of the *alveolar processes* covers the alveolar bone in a thin, but firm and taught layer. It is directly grown together with the underlying periosteum, not covering any fatty, connective or muscular tissue. It is liberally supplied with bloodvessels and contains a large number of mucus and lymph glands. At the line of reflection ("conjunctiva"), the mucosa continues over to the soft muscular covering of the jaws. Hence injections in the areas of the bony alveolus are made into the periosteum underlying the taught mucosa, and with a certain amount of pressure in order to reach through the bone the deeper strata which contain the nerve fibers to be anesthetized.

In practice, injections in the taught alveolar mucosa are rarely used except, perhaps, for purely mucous anesthesia in operations on the interdental papilla or the circular ligament. For the purpose of anesthetizing deeper tissues such as bone and teeth, the injection has to be advanced beyond the *line of reflection*, thus inducing an infiltration anesthesia under mild pressure which in reality represents a conduction anesthesia. While advancing the needle, the solution is *slowly discharged under moderate and even pressure*. Presently the mucosa over the bony area is raised in form of a swelling which readily disappears, especially if this edema wheal is massaged gently. The pink mucosa rapidly grows pale from the action of the suprarenin and assumes a white color in successful cases.

The *oral mucosa* is subject to variations according to an individual's state of health and the presence of alveolar or dental pathology. It appears now firm and resistant, now loose and spongy, now robust and thick, now extraordinarily delicate and thin. Occasionally, the mucosa has so little resistance that it tears even under most cautious injection or allows the solution to run out of the torn aperture. In some cases, an apparently normal mucosa retains and diffuses solution only upon high injection in the mucous fold. It appears as if the mucosa together with its periosteal substratum could easily be lifted from the bone instead of adhering to it tightly. This unfavorable condition of the mucosa is observed especially in persons of advanced age.

In every case the anesthetic effect is due to the contact of the injected solution with the sensory nerve fibers, which are gradually paralyzed within from five to ten minutes, depending upon the anesthetic employed. If injected correctly, our novocain-suprarenin solution produces complete anesthesia of the injected area within from eight to ten minutes. The anesthesia maintains its full intensity for about half an hour, after which time it wears off very gradually.

FIG. 75

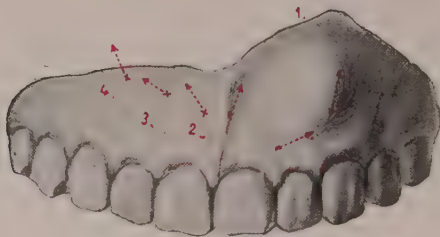


Mucous anesthesia in the maxilla in case of abscess of the root of the upper left canine. The needle is inserted in the gingival papilla of the central incisor and advanced horizontally in distal direction. The syringe is held like a penholder.

**Injection in the Mucosa.**—The syringe is held like a penholder (see Fig. 75), and the needle is placed at an almost right angle upon the mucosa, which has previously been disinfected with tincture of iodine. The needle is then slowly pushed through the gingiva and the

periosteum, and the syringe is inclined so that the needle forms an acute angle with the bone (see Figs. 76 and 77). The syringe is then held in this position with the left hand, while the right hand moves back along the barrel until it engages the piston handle and cross bar between the thumb and the index and middle fingers.

FIG. 76



Points of injection for anterior upper teeth. 1, injection for abscessed upper left lateral incisor; 2, injection for upper right central and lateral incisors; 3, injection for upper right canine; 4, injection for upper right bicuspid. The red crosses indicate the points of injection, the red arrows the direction of the needle.

FIG. 77

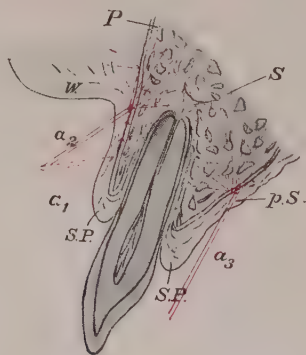


Diagram showing infiltration in upper jaw. Red arrows indicate correct direction of needle.  $a_1$ , insertion of needle;  $a_2$ , further progress of needle buccally;  $a_3$ , position of needle palatally;  $P$ , periosteum;  $W$ , soft tissue at mucous fold;  $S$ , spongiöse portion of maxilla;  $p.S.$ , palatal mucosa;  $S.P.$ , mucous papilla.

The syringe is mounted with hub  $B$  or  $C$  and needle No. 17 (see Figs. 78 and 79). The orifice of the needle should always point toward the bone in the manner illustrated in Fig. 80. When anesthetizing individual teeth, hub  $B$  is employed to advantage (see Fig. 78), as it allows of the use of the entire needle length in advancing under the

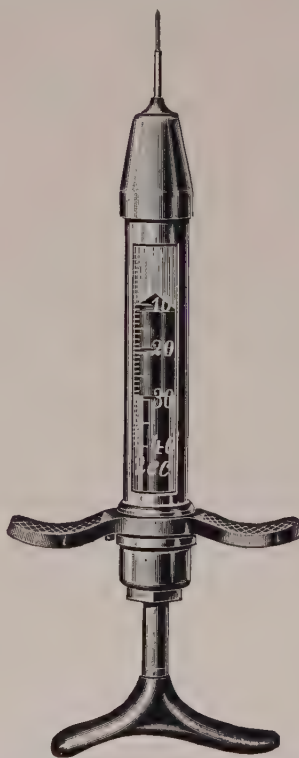
mucous fold. With the fingers of the left hand, the lip is lifted up as high as possible to gain an unobstructed view and the contents of the syringe is discharged while slowly advancing and receding. As soon as the needle has emerged from the mucosa, the point of insertion is immediately covered with the index finger of the free hand and compressed for a few moments under gentle massage. This will readily reduce the wheal which appears after every injection above the line of reflection.

FIG. 78



Syringe with hub B and needle No. 17.

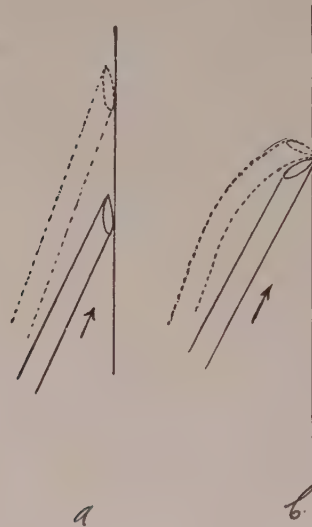
FIG. 79



Syringe with hub C and needle No. 17, for infiltrations.

For injections in the middle or posterior portion of the alveolar process of the upper jaw, the thicker and long needle No. 1 with hub *B* is preferred, to facilitate the farther and higher advance of the needle upon the bone (see Fig. 82). In the posterior area we have to reckon

FIG. 80



Position of the needle in mucous anesthesia, the aperture of the needle pointing toward the bone; *a*, correct position; *b*, incorrect position. The point of the needle is forced into the periosteum and to the bone. (After Seidel.)

FIG. 81

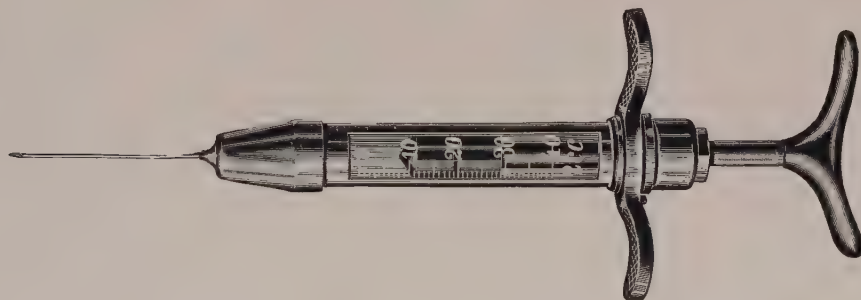


Points of injection in the maxilla in mucous and conduction anesthesia. *U*, line of reflection of mucous membrane; 1, injection for upper right central incisor; 2, for upper right lateral incisor; 3, for conduction anesthesia of upper right lateral, canine, and first bicuspid, the needle to be advanced to the infraorbital foramen; 4, for upper right second bicuspid; 5, for upper right first molar; 6, conduction anesthesia at maxillary tuberosity for upper right first, second, and third molars; 7, conduction anesthesia for upper right third molar.

with resistance of the tuberosity which permits the needle to advance at an acute angle only. The long needle also gives us a wide range over the root apices of the teeth, and avoids unnecessary new insertions in the mucosa.

**Maxilla.**—*Buccal and Labial Injection.*—Injections in the mucosa also are generally made in the manner just described. Repeated insertions of the needle should be avoided as much as possible, and an effort be made to infiltrate the desired area at one insertion, which is always possible in single teeth. The anesthetization even of several teeth can be accomplished at one insertion, especially in bicuspid and molars, which allow of nearly straight advancement of the long needle (see

FIG. 82



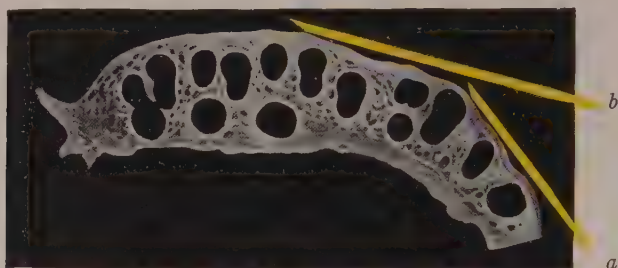
Syringe with needle No. 1 and short hub B.

Fig. 83). The needle is always inserted at the level of the middle root portion at a right angle to the long axis of the teeth, and advanced upon the bone, viz., in the periosteum to above the root apices (see Fig. 83).

At the sharp curve in the canine region, however (see Fig. 83), the needle is inserted at the level of the root apex of the canine and advanced in the direction of the canine fossa into the depth of the gingiva, where the injection is slowly made under pressure (see Fig. 84). If the incisors and bicuspid also on the same side are to be anesthetized, the needle is first pushed forward from the canine root, slowly discharging the contents of the barrel, in the direction of the anterior nasal spine to the region of the root apex of the central incisor, where the remainder of the solution is injected (see Fig. 81). After the syringe

has been refilled, the needle is then again inserted at the former point at the canine root, and advanced in the direction of the root apices of

FIG. 83



Position of the needle for horizontal injection in several upper teeth. Needle yellow; *a*, labial injection; *b*, buccal injection.

FIG. 84

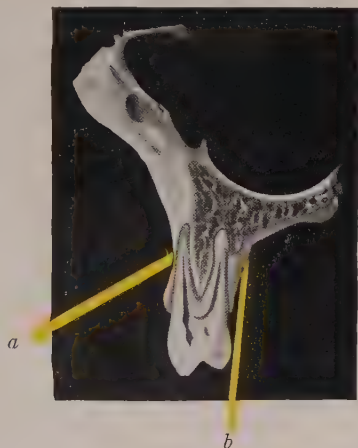


Position of the needle for injection in upper canine. Needle yellow; *a*, labial injection; *b*, palatal injection.

the bicuspid, where the barrel is again slowly discharged. If the second bicuspid also is to be anesthetized, the needle must be advanced to the root apex of that tooth (see Fig. 85).

If the gingival tissue is normal and the injection has been made slowly, no excessive wheal is usually raised, and the formerly pink mucous membrane rapidly becomes pale. In spongy gingival tissue, however, the formation of a prominent wheal cannot be prevented. In general this submucous tissue should be infiltrated very slowly and under cautious pressure. Rapid injections invite tearing and other injuries of the tissues, and prevent the full effect of the solution as its diffusion remains altogether too superficial. The gradual expansion of the anemic area should always be carefully noted.

FIG. 85



Position of the needle for mucous anesthesia in upper first bicuspid. Needle yellow. Above is seen the infraorbital foramen: *a*, buccal injection; *b*, palatal injection.

The anterior teeth or bicuspid can be anesthetized, without resorting to blocking at the infraorbital foramen, by injecting a fairly large quantity of solution (from 2 to 2.5 c.c.) in the canine fossa. To do this, the needle is inserted high in the mucous fold above the first bicuspid root and advanced upward 1.5 to 2 cm. upon the bone in the direction of the lower border of the orbit. After inundating the canine fossa, small deposits of solution are made at the root apices of the teeth to be anesthetized.

**Palatal Injection.**—For palatal injection the needle is always inserted in the mucosa at the middle root portion behind the tooth to be anesthetized (see Figs. 77, 83 to 86) and is at once cautiously and slowly advanced parallel with the alveolar process to the vicinity of the root apex (see Figs. 77 and 87), where a small quantity of the solution, *i. e.*, from 0.25 to 0.5 c.c., is deposited (see Fig. 76). In the gingiva

FIG. 86



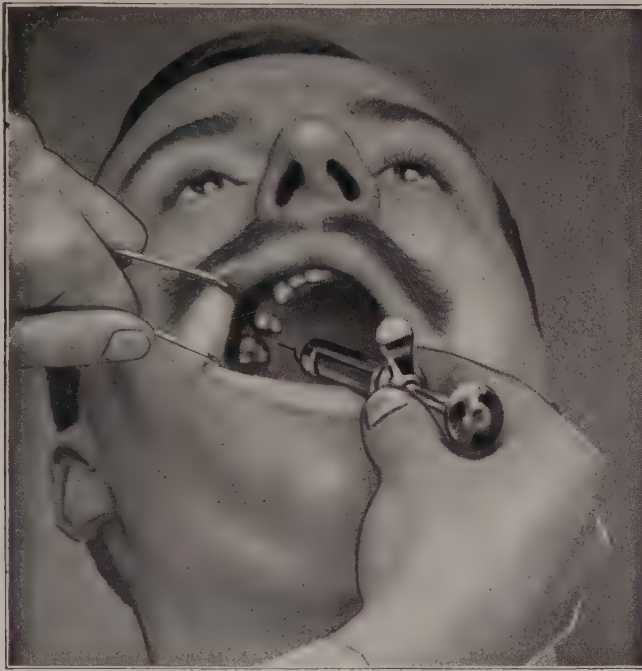
Injection in the palatal mucous membrane at the lateral incisor. The syringe is held like a penholder.

of the upper jaw, the solution diffuses most readily without requiring an undue amount of pressure or causing any untoward sequelæ.

This form of palatine injection is practical in single teeth only. If the palatal mucosa of several upper teeth is to be anesthetized, we resort most successfully to conduction anesthesia of the anterior palatine and nasopalatine nerves.

Injection at the posterior palatine foramen completely blocks the anterior palatine nerve which is distributed on both sides over the palatal roof up to the canine region. This nerve supplies only the gingival mucosa, periosteum and bone, but not the teeth, hence it need be intercepted only in extractions and such surgical interventions as extend to the palatal mucosa.

FIG 87



Injection in the palatal mucous membrane in the bicuspid region. The syringe is held like a penholder.

*Injection at the Posterior Palatine Foramen.*—One single injection at the posterior palatine foramen usually suffices. This foramen is situated under a slight depression in the mucosa near the palatal root apex of the third molar (see Fig. 91). When looking carefully at the palatal roof, on a line drawn across from third molar to third molar, we usually observe a well marked slight indentation of oval shape closely in front of the tuberosity and above the apical root end of the third

molar. The deepest point of this indentation is the point for insertion of the needle.

The posterior palatine foramen is usually located  $\frac{1}{2}$  cm. from the palatal border of the alveolar process and above the last erupted molar (see Figs. 55, 89 and 91), viz., up to the tenth or eleventh year above the first molar, after the eruption of the second molar above this tooth, and finally, above the third molar (see Figs. 32 to 35, 55 and 81).

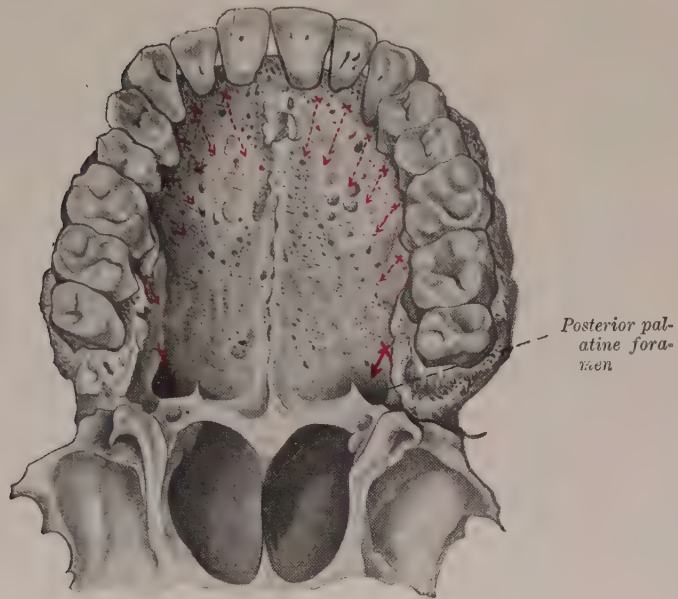
FIG. 88



Course of the incisive canal in the maxilla. (Raubert-Kopsch). 1, Lacrimal sulcus; 2, ethmoidal crest; 3, crest of concha; 4, nasal crest of palatal process; 5, incisive canal; 6, alveolar process; 7, maxillary sinus; 8, nasal aspect; 9, pterygopalatine sulcus.

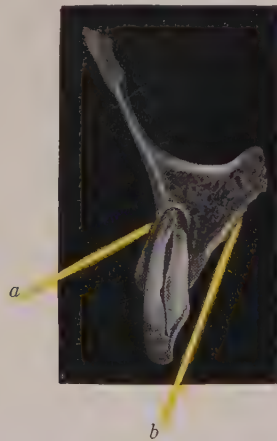
The needle is inserted into the depression in the mucosa at about the level of the palatal root apex of the last molar, the syringe being directed almost parallel to the alveolus and the molar root and inclined slightly backward toward the tuberosity; the needle is then advanced to the foramen and a small quantity of solution is evacuated. The discharge of a larger quantity involves danger of the solution diffusing into the loose tissue of the soft palate and causing disagreeable difficulties in

FIG. 89



Bony surface of palate. The red crosses indicate the points of injection for mucous anesthesia; the solid red arrows the points of injection at the posterior palatine foramina.

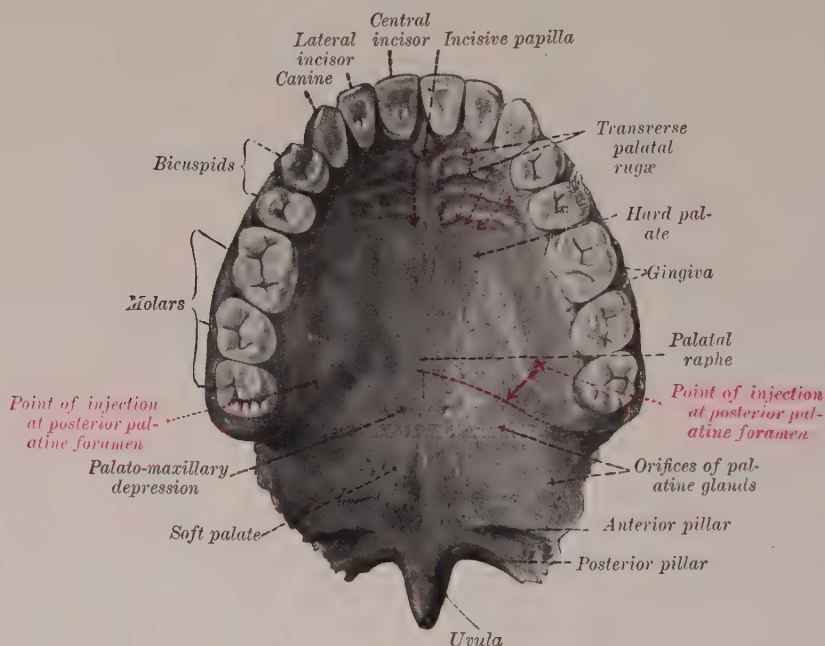
FIG. 90



Position of the needle for injection in upper central incisor. Needle yellow: *a*, labial injection, *b*, palatal injection.

deglutition. Strictly speaking, a conduction anesthesia is induced by this method, as the anterior palatine nerve trunk is blocked at its descent from the posterior palatine foramen. The muco-gingival covering of the palate up to the canine on the injected side is completely anesthetized by this injection within five minutes. In the *canine region*, the fibers of the nasopalatine nerve overlap, so that for its anesthetization an infiltration must be resorted to, if we wish to avoid an injection at the incisive foramen which is often quite painful.

FIG. 91

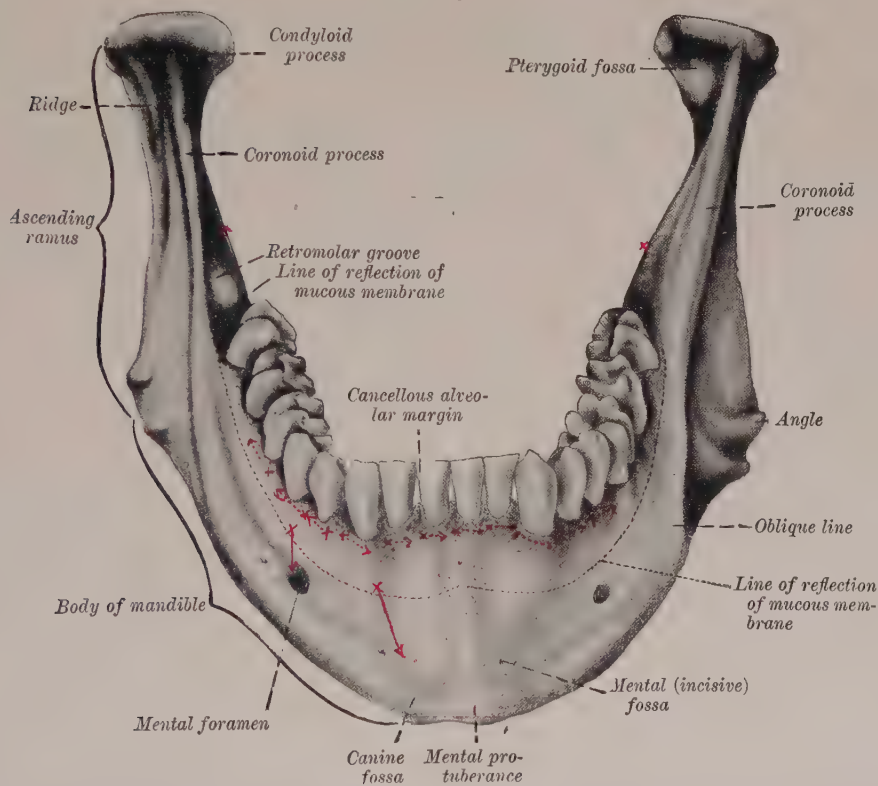


Mucous surface of palate. The red cross marks the point of injection at the posterior palatine foramen on either side. (After Spalteholz.)

Injection at the *incisive (nasopalatine) foramen*, which is situated in the median line in the anterior portion of the palatal roof, can be recommended only under certain conditions, as it is usually painful, and requires considerable pressure to force the solution into the incisive canal. The degree of pain caused by this injection varies greatly in

individuals, from intolerable agony to a light needle prick. If we succeed in introducing from 0.5 to 1 c.c. of solution into the foramen, the palatal roof behind the front teeth becomes deeply anesthetized within a few minutes. In extensive operations, this injection is desirable in combination with the other block injections in the upper jaw so as to render it insensible to its full extent.

FIG. 92



Points of injection for mucous anesthesia in external surface of mandible. Red crosses indicate points of injection; small red arrows, direction of needle; two large arrows, direction of needle for injection in mental foramen and fossa. On the internal surface of ramus are marked the points of injection at mandibular foramen.

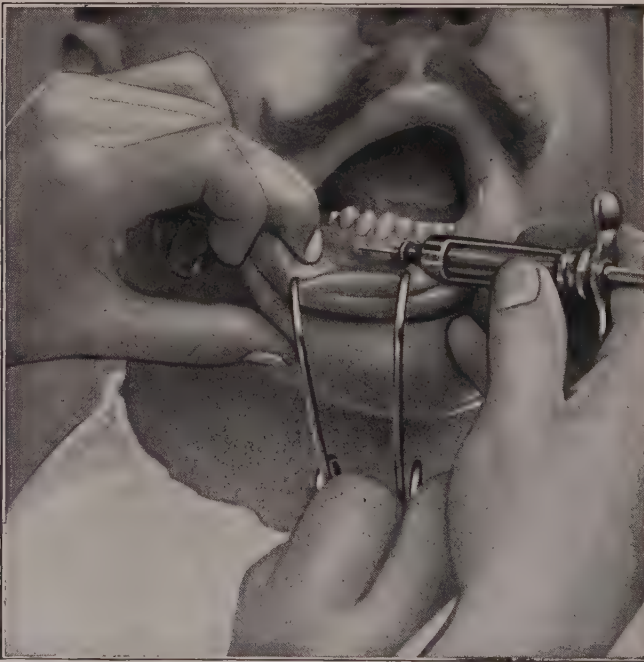
In practice, the needle is inserted directly above the incisive papilla and advanced parallel to the palatine surface of the central incisor. The direction of the syringe is from below outside to upward

FIG. 93



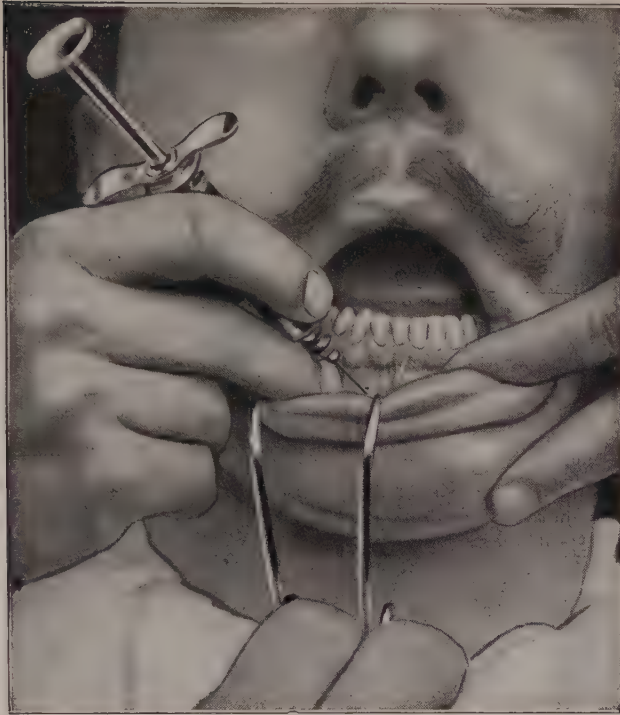
Position of the needle for injection in lower molars. Needle yellow; *a*, buccal injection; *b*, lingual injection.

FIG. 94



Injection in the mandibular mucous membrane for anesthesia of lower second bicuspid. The needle is inserted in the eminence at the first bicuspid directly below the gingival papilla. The syringe is held like a penholder.

FIG. 95



Injection for anesthesia of lower anterior teeth. The long needle is inserted in the reflection of the mucous membrane and advanced to the mental fossa. The syringe is held like a penholder.

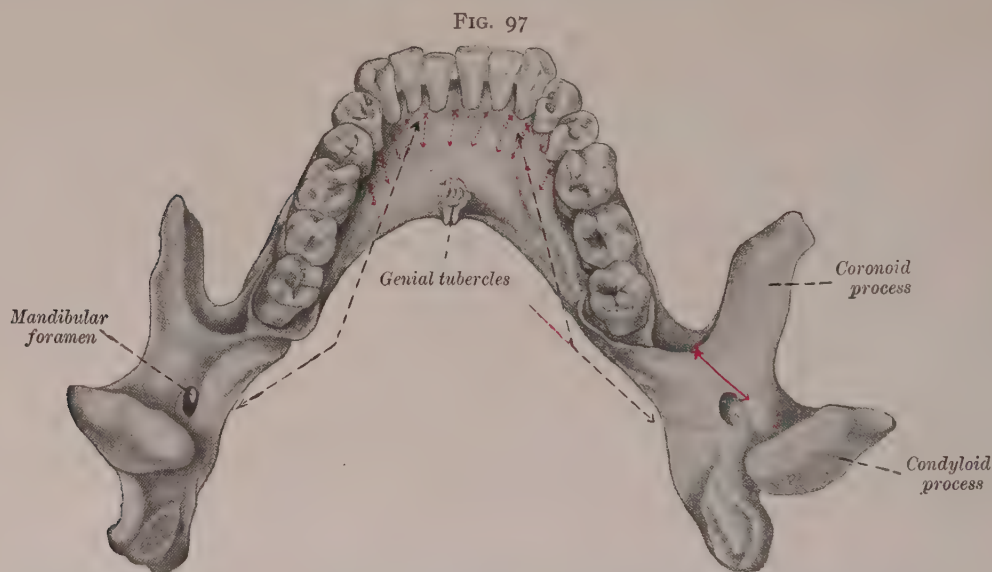
FIG. 96



Position of the needle for injection in lower canine. Injection in mental fossa. Needle yellow. *a*, labial injection; *b*, lingual injection.

and inward, corresponding with the course of the incisive canal which runs from the large incisive (nasopalatine) foramen behind the incisor roots to the floor of the nose.

If we wish to avoid injection at the incisive foramen, we insert our needle, as in injection on the palatal surface of the canine, at the middle of the incisor roots and advance toward the apices (see Figs. 84).



Lingual points of injection for mucous anesthesia of the mandible. Red crosses indicate the points of injection; red arrows, the direction of the needle; black-dotted lines, the angle of the ramus to the body of jaw.

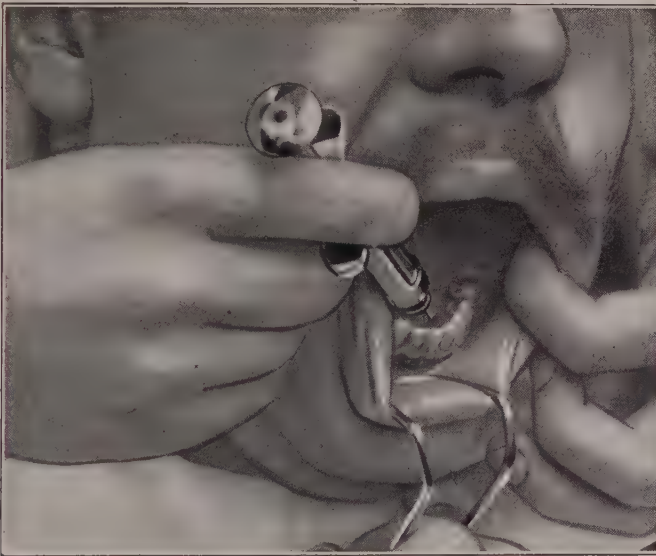
**Mandible.**—In the mandible mucous anesthesia is limited to anesthetization of loose roots and teeth, and may sometimes render good service in the anterior teeth (see Fig. 92).

In the lower deciduous teeth, mucous anesthesia is applicable though in obstinate and fretful children light narcosis is more favorably indicated. In all other cases, conduction anesthesia is preferable in the mandible; even in children from six years on, it can be advantageously employed.

If *infiltration anesthesia* is to be used in the mandible, it should be clearly understood that, owing to the peculiar anatomic nature of the

bone, diffusion of the solution through the bony substance is very doubtful, in most cases impossible; hence no dental anesthesia ensues. Penetration of the injected solution in lower bicuspid and molars is possible only if the injection is made under great pressure at the interdental papilla where the solution can enter the porous outer alveolar wall and diffuse into the fundus of the alveolus. In very young and spongiouse alveolar bone, and in teeth loosely placed in their alveoli, best results will be obtained, but failure will follow in teeth firmly placed in a dense sclerotic jaw.

FIG. 98



Lingual injection between lower canine and bicuspid for anesthesia of lingual nerve fibers. Mucous anesthesia.

Mucous injection in lower teeth is made by inserting the needle in the buccal papilla close to the anterior tooth, advancing it upon the alveolar margin while slowly discharging the solution thus infiltrating the entire alveolar mucosa (see Figs. 94 and 95). Lingually one proceeds in a corresponding manner (see Figs. 97 and 98).

The lower anterior teeth are best anesthetized by injection at the mental fossa.

*Injection at the Mental Fossa.*—The lip is depressed and the needle inserted in the reflection of the mucous membrane, which has been previously sterilized with tincture of iodine, at about the level of the middle root portion of the canine (see Figs. 95 and 96), and pushed inward and downward with a slight inclination mesially, until the *mental fossa* is reached (see Figs. 17 to 23, 25 to 29, 95 and 96). Part of the solution is deposited below the canine root apex, the remainder after changing the direction of the needle below the incisor roots so that a considerable area of bone is flooded with solution. The fossa is situated below the root apices of the canine and the lateral incisor and usually exhibits numerous foramina through which the injected solution penetrates into the interior of the jaw (see Fig. 97). Some solution is discharged while advancing the needle to the fossa; the bulk of solution (from 1 to 2 c.c.), however, is deposited in the fossa itself and invariably produces complete anesthesia of the canine and the two incisors on the injected side. On account of the anastomoses from the opposite side, it is advisable to inject the canine fossa on both sides of the median line, even if only one side is to be operated upon.

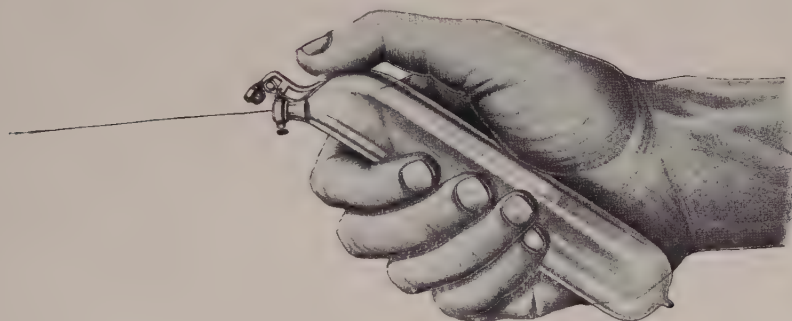
*Lingual Injection.*—Lingually a small quantity of solution is injected behind the central incisors and in the line of their long axis (see Fig. 97), also between the canine and the first bicuspid (see Fig. 98), in order to anesthetize the terminal fibers of the lingual nerve. It may be possible, especially in the young jaw, to force solution through the foramina situated lingually at the genial tubercles (see Figs. 36 and 37). The needle is inserted below the tense gingival papilla of the central incisor, and is at once slowly advanced parallel to the alveolar process, while discharging some solution, to the vicinity of the root apex. An injection is also made between the canine and bicuspid (see Figs. 96 and 98), the needle to be advanced directly to about the middle of the canine root, while slowly discharging some solution; in both cases about 0.5 c.c. of solution is injected. While it is possible, then, in lower anterior teeth to inject locally yet, if several teeth are to be anesthetized at once, it is preferable to resort to conduction

anesthesia, which insures full success even in periostitis, and is attained more rapidly and simply by blocking the entire mandibular nerve trunk, if necessary, on both sides.

*Anesthesia of Lower Molars.*—In the lower molars conduction anesthesia alone is indicated.

**Anesthesia in Inflammatory Conditions.**—*Mucous Anesthesia in Inflammatory Swelling.*—In cases of gingival or alveolar abscess, conduction anesthesia should always be first attempted. If this, however, is unsuccessful or contraindicated, mucous anesthesia by infiltration of the sound environment of the pathological field may be resorted to.

FIG. 99



Position of the ethyl chlorid flask when spraying. (Preisweck.)

*Anesthesia by Ethyl Chlorid.*—In the anterior teeth, both upper and lower, the old ether spray method can often be employed with great success. The mucosa is carefully dried and disinfected with tincture of iodine; right and left of the field of operation the gingivæ are padded with cotton rolls in order to keep away the saliva as much as possible, the tongue is covered with a small mouth napkin, and the ethyl chlorid spray from an automatically closing flask is directed against the mucous membrane, from a distance of from 20 to 30 cm. If perfectly dry, the mucosa is rapidly covered by a crust of ice and congealed and blanched. After about one minute the tooth can be extracted, and in most cases such operations are painless, or at least very tolerable (see Fig. 99).

In extracting putrescent deciduous teeth this method is particularly practical, since the ether inhaled by the child produces a light narcosis sufficient to render the operation painless. Ethyl chlorid is indispensable also in severe putrescent conditions, in incisions for gumboils, or in extraction of loose putrescent anterior teeth or roots. In such cases anesthesia by local injection would be detrimental rather than useful.

*Injection in Swollen Areas.*—If, nevertheless, mucous injection is preferred to the far more efficacious and safe conduction method, the injection must always be made in healthy mucous membrane in the vicinity of the focus of infection (see Figs. 75, 76 and 100). In such cases, however, several peripheral injections on each side of the abscess must be made, and care exercised, lest the needle in its advance penetrate the pathological tissue. This involves the risk of sepsis which in several cases of injudicious injection has led to fatalities.

FIG. 100

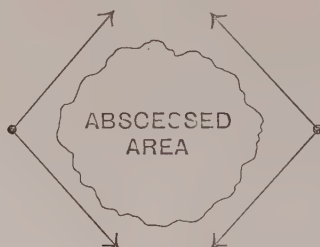


Diagram showing method of peripheral injections in abscessed areas.

Figure 76, illustrates the method of anesthetizing a putrescent upper lateral incisor when swelling is present. One injection is made above the central incisor in the direction of the anterior nasal spine and the root apex of the tooth, a second above the canine, the needle to be advanced in the direction of the canine fossa. Under no conditions must the needle be allowed to come in contact with an abscess area. In all these cases the needle is advanced directly to the periosteum, and the solution is injected slowly and under moderate pressure. As soon as the patient perceives a painful sensation of tension, the injection at that point must be immediately discontinued.

*Period of Waiting.*—In all cases of mucous anesthesia, a waiting period of from eight to ten minutes should be allowed. Disregard of this important postulate of a sufficient waiting period is responsible for many failures. Since the waiting period varies with individuals, the mucosa within the field of operation should be carefully tested. The anesthesia lasts from thirty to sixty minutes.

**Principles of Mucous Anesthesia.**—Besides the cautionary measures enumerated before, such as asepsis, isotonia of the solution, etc., the following technically important factors must be observed to insure successful mucous anesthesia:

1. Thorough sterilization of the mucosa with tincture of iodine (decolorized iodine or thymol-alcohol).
2. One injection on each side of the jaw; the fewer needle-pricks the better the effect.
3. The orifice of the sterile needle (preferably of iridio-platinum) must always point toward the bone.
4. Moderately strong pressure and very slow injection.
5. After inserting, contact with the bone is sought and the needle advanced over the bone, eliminating uncertainty of injection.
6. Compression of the point of injection with the finger tip after withdrawal of the needle.
7. A waiting period of from eight to ten minutes.
8. The patient should be kept under observation after the injection.

## PERIDENTAL AND INTRA-OSSEOUS INJECTIONS.

**Peridental Injection.**—The methods of peridental and intra-osseous anesthesia are here mentioned merely for the sake of completeness; for practice they are to be discountenanced, since they offer no advantage whatever, and are complicated and dangerous. Peridental anesthesia, which has been recommended by various writers, is best described by H. Prinz:<sup>1</sup>

<sup>1</sup> Dental Summary, March, 1912, p. 167.

"Teeth or roots standing singly, or teeth affected by pyorrhea or similar chronic periodontal disturbances, are frequently quickly and satisfactorily anesthetized by injecting the fluid directly into the periodontal membrane. This method is known as periodontal anesthesia, and its technique is very simple. In single-rooted teeth a fine and short hypodermic needle is inserted under the free margin of the gum, or through the interdental papilla, into the periodontal membrane between the tooth and the alveolar wall. Sometimes the needle may be forced through the thin alveolar bone so as to reach the periodontal membrane directly. To gain access to this membrane, in teeth set closely together, separation is essential. It may be accomplished with an orange-wood stick or by any of the various mechanical separators. By so doing the body of the tooth is shifted to one side, thereby creating a slight space between it and the alveolar process. The injection is now made directly into the exposed periodontal membrane. By reversing the separator, the tooth is shifted to the opposite side, and the injected liquid is forced toward the apex of the tooth. A second injection is now made in this freshly exposed portion of the periodontal membrane. Two, sometimes three, injections are necessary. To force the liquid into the membrane usually requires a higher pressure than that which is necessary for injecting into the periosteum covering the alveolar process, but the quantity of the anesthetic liquid is less than that which is required for the former injection. Acute inflammatory conditions of the periodontal membrane and its sequelæ prohibit the use of this method. Periodontal anesthesia is the purest form of local anesthesia, since the seat of the nerve supply of the tooth is very quickly reached, and as a consequence the results obtained are in the majority of cases extremely satisfactory, provided that general conditions justify its application. The method is specially serviceable for the removal of pulps in all such cases where contact anesthesia is not indicated, or for temporarily desensitizing a tooth for operative procedures."

This description of periodontal injection contains, step by step, a condemnation of that method. It is evidently harmful and dangerous to inject any solution directly into an infected field, such as may

surround teeth or single roots affected by pyorrhea or similar chronic periodental disturbances; for infectious material is invariably carried to deeper strata, especially under the great pressure required in this form of injection. This procedure cannot but produce severe after-pain, sloughing, necrosis, or constitutional septic symptoms, all of which misfortunes are then usually laid at the door of "the toxicity of the anesthetic." The procedure of separating the teeth in order to gain access for the insertion of the needle between the tooth and the alveolar process is dreaded by every patient, and the preliminary measures for preparing the field for injection involved in this method are almost as painful as the operation would be without the local anesthetic, while submucous and conduction injections as advocated in this book, if executed correctly, produce no pain whatever. The fact that a slightly smaller quantity of anesthetic solution is required is a negligible factor, considering the very small doses required in the methods advocated herein, which are so very far below the toxic limit. In healthy single teeth periodental injection is painful owing to the extremely tense nature of the membrane, which, moreover, it is an accepted rule not unnecessarily to injure, as such injury may prove fatal to the life of the tooth.

**Intra-osseous Injection.**—Intra-osseous injection, for the purpose of hastening the diffusion of the anesthetic solution, was suggested by Otté in 1896, and again, independently of him, by A. H. Parrott.<sup>1</sup> Various modifications of this method have been proposed, as, for instance, by B. H. Masselink, Hein and Smith.<sup>2</sup> The technique of this method is as follows, excluding minor details: "After the gum tissue is thoroughly cleansed with an antiseptic solution, it is anesthetized about the neck of the tooth in the usual manner. After waiting two or three minutes, an opening is made into the gum tissue and the bone on the buccal side with a round bur, a fine spear drill or a Gates-Glidden drill. The opening should be made more or less at a right angle, with the long axis of the tooth a little below the apical foramen in single-rooted teeth, or between the bifurcation in molars. The right-angle hand-piece is preferably employed for this purpose. The drill should be

<sup>1</sup> British Dental Journal, August 16, 1909.

<sup>2</sup> Dental Cosmos, August, 1910, p. 868.

of the same diameter as the hypodermic needle. The gum fold is tightly stretched to avoid laceration for the rapidly revolving drill. As soon as the alveolar process is penetrated, a peculiar sensation conveyed to the guiding hand indicates that the alveolus proper is reached, and the sensation felt by the hand is about the same as that experienced when a bur enters into the pulp chamber. In this artificial canal the closely fitting short hypodermic needle with a blunt point is then inserted, and the injection is made in the ordinary way."<sup>1</sup>

From this description it is self-evident that the method of intra-osseous injection is complicated and risky. Inasmuch as a preliminary injection is required for the painless employment of the bur, this injection might as well be executed in such a manner as to render any adjuvant injection unnecessary. The uncertainty of the effect of the bur upon the tissues within the alveolus; the danger of lacerating the gingiva, or injuring nerves or bloodvessels; the probability of infection by way of the handpiece, that bugbear of sterilization; the not inconsiderable lesion produced by the bur, which is not justified by the result to be attained; the obscurity in regard to the actual topography of the root, if no radiograph is available, and the likelihood of a disturbed healing process—all these considerations characterize the intra-osseous method as one *in nuce*.

### CONDUCTION ANESTHESIA.

An anesthetic solution when injected in the vicinity of a fair-sized nerve trunk, penetrates by way of the perineurium into the central nerve substance, inhibiting its function, and anesthetizing the entire peripheral area supplied by that nerve. Owing to this elimination of the conductivity of the nerve trunk, sensory irritations of its terminal fibers are no longer perceived in the central organ. "The sensory nerve tracts are extremely susceptible to anesthesia by perineural injection, if their minute terminal branches are inundated with an anesthetic solution; conduction anesthesia, on the other hand, is more difficult,

<sup>1</sup> Prinz, Dental Summary, March, 1912, p. 169.

ensues more slowly, and requires a larger quantity and a higher concentration of anesthetic solution, the farther away from the terminal distribution of the nerves, *i. e.*, the nearer to the spinal column an injection is made." (Braun.)

This contention is fully borne out by practical experience with anesthesia of the jaws.

Anesthetization of the nerve plexuses in the *periosteum*, the *pericementum* and the *pulp* is produced by a simple infiltration which acts as a nerve block by conveying the anesthetic solution more or less directly to small nerve trunks, inundating them and depriving them of conductivity. The nervous end organs in the pulp and the pericementum are not reached directly by the solution, but they are anesthetized by the interception of the conductivity of a nerve trunk remote from its final distribution. The more closely we get to the individual fibers, and the more delicate these are themselves, the more rapidly and certainly anesthesia will be established.

Every peripheral nerve is surrounded by a stout connective tissue sheath, the *perineurium*, which offers great resistance to the penetration of the diffusing solution. The thickness, therefore, of this nerve sheath decides the quantity and the concentration of the solution to be injected, also the choice between *endoneural* injection, in which the solution is deposited through the sheath directly in the nerve itself, or *perineural* injection, where its environment only is injected. The latter method requires considerably greater quantities of solution.

Perineural conduction anesthesia is applicable only in nerves of moderate thickness. It represents a localized infiltration anesthesia, as it were, inasmuch as we flood the presumable vicinity of the nerve with a liberal quantity of solution.

To illustrate: Injection at the maxillary tuberosity by which a number of fine fibers is reached upon the bony surface, yields a rapid anesthesia in from five to ten minutes, while the blocking of the much stouter mandibular nerve may require from twenty to thirty minutes until anesthesia is established. In the region of the upper anterior teeth, the solution must first penetrate the porous bone before reaching the nerve fibers running beneath it to the pericementum and the pulp,

hence anesthesia will be slower than when an injection is made at the incisive (nasopalatine) canal or the infraorbital foramen where we can directly inundate the unprotected nerve fibers.

**Special Topography of the Maxilla and Mandible.**—The anatomic details described below have been compiled with the coöperation of the Marburg Anatomic Institute. The illustrations are reproductions of original specimens made by Professor Gasser, who has made specially careful investigations of our field of operation. According to this expert in anatomic technique, the topography of the portions concerned in local anesthesia can be determined, in addition to visual examination and palpation in the living, in the following manner:

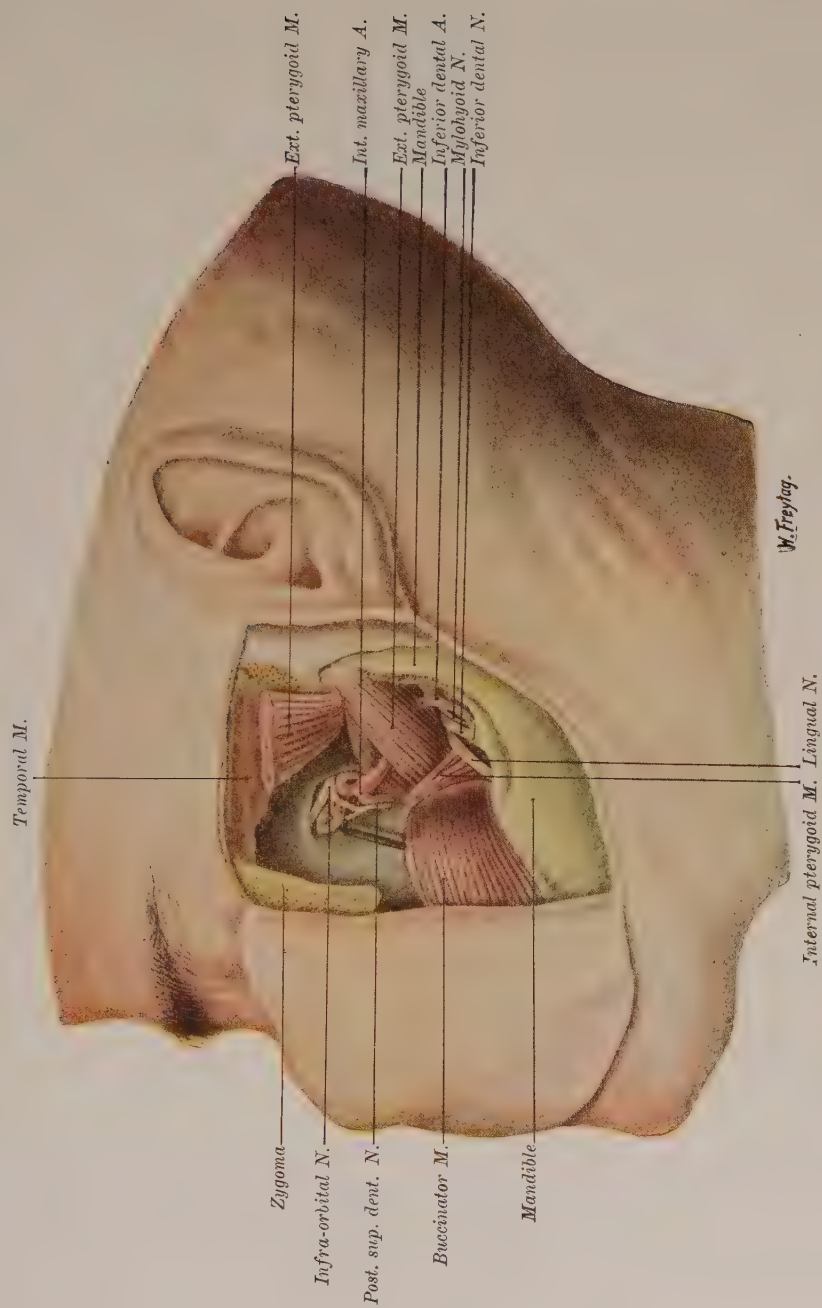
1. By sections through the region to be studied; if practical, by frozen sections;

2. By dissected specimens.

The former method affords a most accurate insight into the anatomic arrangement of the part, since nothing is dissected away; each section, however, shows only one level. The latter method offers the advantage of a comprehensive survey of the entire part. Both methods have been used.

*Superior Maxillary or Infraorbital Nerve.*—The topography of the *superior maxillary* or *infraorbital nerve*, as it passes through the infraorbital canal in the floor of the orbit, is shown in Fig. 101. In the specimen illustrated, the zygomatic arch together with the masseter muscle is removed, first exposing the mandible and the temporal muscle. The anterior portion of the ascending ramus and the head of the temporal muscle are removed next. In this way the pterygoid fissure with the *lingual* and *mandibular nerves* and the *inferior dental artery* are exposed. The upper portion of the external pterygoid muscle is reflected. The posterior portion of the buccinator muscle is shown with its characteristic curvature before it continues downward and backward. This curvature, which is in direct contact with the mucosa of the cheek, indicates the lateral and posterior border of the oral cavity. Above the buccinator muscle appears the *maxillary tuberosity*, above which the entrance to the *infraorbital canal* is situated. Behind lies the pterygoid process and the pterygopalatine fossa, covered by the maxillary bone.

FIG. 101



Topography of the maxillary tuberosity, with special consideration of the nerves and bloodvessels at the ascending ramus. (Gasser.)



The arch of the *internal maxillary artery* disappears in the pterygoid-palatine fossa. The *infraorbital* and the *posterior-superior dental nerves* are visible. It should be remembered that the superior dental nerves are branches of the infraorbital: the *posterior-superior dental nerves* arise from the trunk of the nerve just as it is about to enter the infraorbital canal, and pass downward on the maxillary tuberosity; the *middle* and *anterior-superior dental nerves* are given off in the infraorbital canal in the floor of the orbit and enter special canals in the anterior wall of the antrum.

Hence, at the spot illustrated in Fig. 101, we meet all superior dental nerves united in the trunk of the infraorbital nerve. The road to this spot is extremely simple. In the posterior upper corner of the vestibule of the mouth, laterally of the upper molars, we palpate the inferior border of the maxillary tuberosity, above which, at a distance of from 2 to 2.5 cm., the desired point is reached, as illustrated by the needle shown in Fig. 101.

The question now arises, What tissues are to be penetrated, and what precautions are necessary?

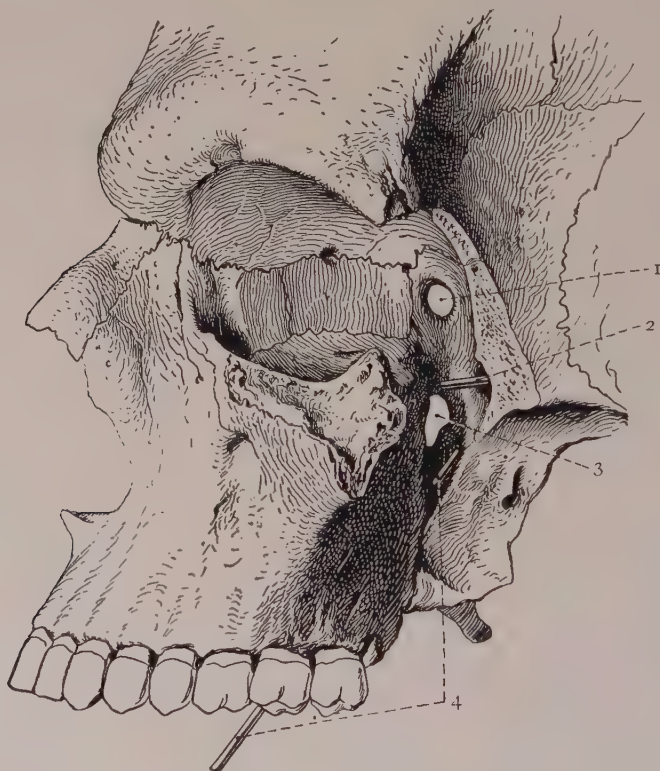
After the needle has passed through the *mucosa* and the thin fibers of the *buccinator muscle*, it encounters only *loose connective tissue*. Fibers of the *external pterygoid muscle* at the margin of the infraorbital fissure are avoided by keeping the needle in close touch with the bone. Some hesitancy may be entertained in regard to the *internal maxillary artery*. To avoid possible trouble, the rule is never to advance the needle more than from 2 to 2.5 cm. upward and backward from the mucous fold.

In blocking the upper and lower dental nerves there is a possibility of injuring a bloodvessel and producing a hematoma. This danger is minimized, however, if an unnecessarily deep advancement of the needle is avoided; it is entirely eliminated if needles and hubs of suitable length are used.

**Injection at the Maxillary Tuberosity.**—*The Maxillary Tuberosity.*—Behind the zygomatic process and above the root apices of the upper molars, numerous foramina are found in the alveolar process, through which stout nerve branches, the *posterior-superior dental nerves*,

enter the maxilla, after having run for a short distance with the main trunk, the *superior maxillary* or *infraorbital nerve*, on the bony surface of the tuberosity (see Figs. 53, 56 and 57). These nerves supply the three molars with sensory fibers. Behind the tuberosity lies the spacious pterygopalatine fossa where the maxillary nerve can be blocked above its entrance into the maxilla (see Fig. 102).

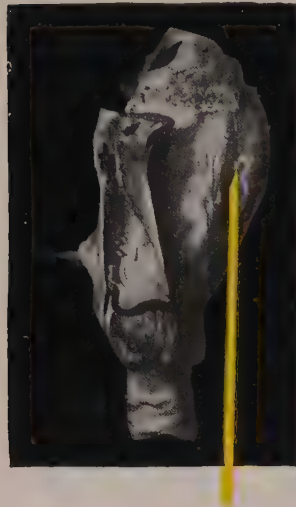
FIG. 102



Pterygopalatine fossa exposed by resection of zygoma. (Sicher.) 1, Optic foramen; 2, probe in foramen rotundum; 3, sphenopalatine foramen; 4, pterygopalatine canal with probe.

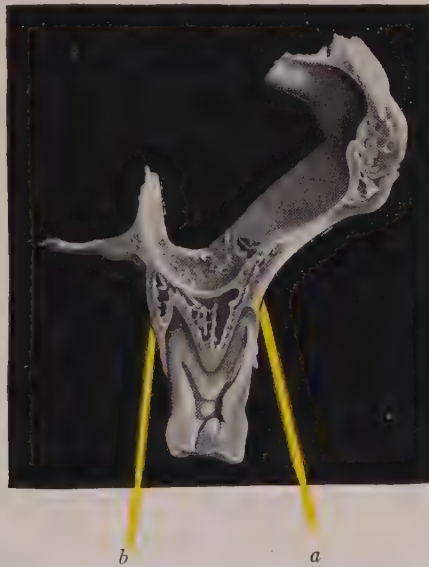
*Technique of Injection.*—The injection is made by inundating the tuberosity with solution, thereby infiltrating the thin anterior wall of the antrum and the nerve fibers passing through it to the molars. If the needle is advanced to sufficient height, it meets the small nerve

FIG. 103



Position of the needle for injection at the maxillary tuberosity. Needle yellow.

FIG. 104

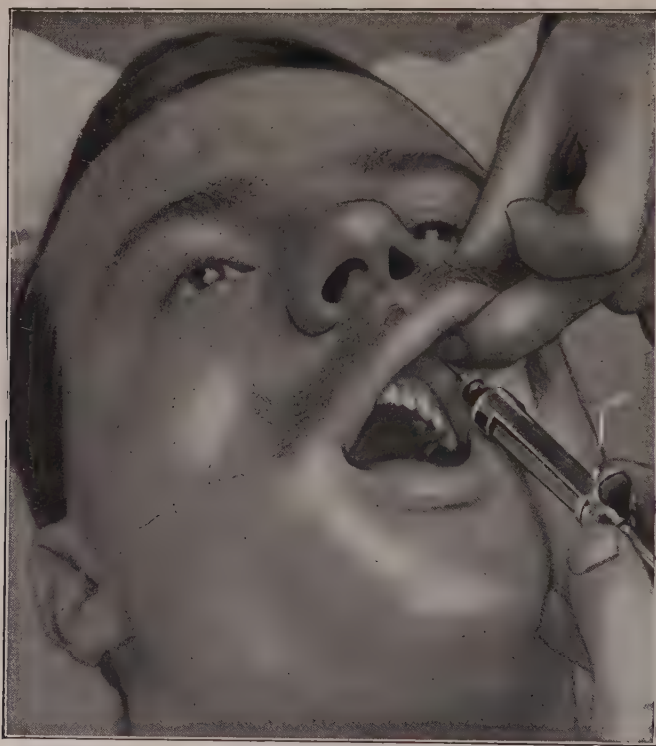


Position of needle for injection in mucous anesthesia of upper first molar. Needle yellow.  
*a*, buccal injection, *b*, palatal injection.

trunks running to the teeth directly upon the surface of the bone, thus ensuing rapid and profound anesthesia.

In the half-open mouth the zygomatic process is palpated, its prominent border fixed with the index finger, the cheek drawn upward, and the long needle No. 2, mounted upon the syringe with hub *C*, is

FIG. 105



Conduction anesthesia at the infraorbital foramen.

introduced high up in the reflection of the mucous membrane at an acute angle to the bony surface not parallel with it (see Fig. 103). The needle is then advanced with a slight backward and upward inclination (see Fig. 81, red arrow No. 6), holding the syringe away from the maxilla, but keeping the needle as close as possible to the slightly convex tuberosity (see Fig. 103).

This convexity of the tuberosity varies considerably and sometimes causes difficulties in injections. It is not always possible, especially if the cheek is very taut, to advance closely to the bone, so that there is danger of injecting into muscles or other tissues. Behind the malar bone there is situated the well defined superior-posterior alveolar artery, in the upper portion of the pterygopalatine fossa the internal maxillary artery. Faulty injection, therefore, may cause a hematoma.

As soon as the long needle has disappeared to its full length in the mucosa, 2 c.c. of solution are discharged. Infiltration buccally at about the middle of the molar roots is not necessary, but guarantees absolute success.

Palatally, an injection into the mucosa, as described on page 185, is made at the *posterior palatine foramen* (see Figs. 89 and 91). Within ten minutes, as a rule, complete anesthesia of the three upper molars ensues.

**Infraorbital Injection.**—*The Infraorbital Foramen.*—The anterior region of the maxilla is dominated by an easily reached nerve plexus, the *anterior-superior dental nerves* (see Figs. 53, 57 and 64). These are given off from the infraorbital nerve just before its exit from the infraorbital foramen, and, entering a special canal in the anterior wall of the antrum, divide into a series of branches which supply the canine and incisor teeth (see Figs. 53 and 57). From the infraorbital foramen emerge the infraorbital nerve and bloodvessels which latter ramify and terminate in the cheek. The foramen itself represents the orifice of the infraorbital canal, the direction of which is shown in Fig. 106. Moral has shown that, with the customary method of injection, some of the solution invariably enters the canal, even though the operator's technique be not quite perfect. In acute periostitis or abscess, injection at the root apices of canine and incisors is contraindicated, as it involves a risk of sepsis. In many cases it is not necessary to deposit the solution higher than in the canine fossa to produce a satisfactory anesthesia of the anterior teeth.

*Technique of Infraorbital Injection.*—The inferior border of the orbit, below which the anterior orifice of the infraorbital foramen is situated, is palpated, and the tissue overlying the foramen is com-

pressed with the thumb of the left hand, at the same time drawing the lip upward and away from the gum with the third finger (see Fig. 105). Many operators find it more convenient to palpate the foramen with the index finger and raise the lip with the thumb of the left hand. The infraorbital foramen is found  $1\frac{1}{2}$  cm. below the inferior border of the orbit, and almost exactly above the first bicuspid (see Figs. 105, 106 and 107). The long needle in hub *C* is inserted in the reflection of the

FIG. 106



Orifices of infraorbital foramen, showing mesial direction of canal. (Sicher.)

mucous membrane over the first bicuspid, and close to the lip muscles, somewhat away from the maxilla, and advanced obliquely upward and slightly backward. As soon as the long needle is felt below the compressing finger tip, from 0.5 to 1 c.c. of the solution is slowly injected. After the injection, massage over the infraorbital foramen is applied to good advantage. As the intention is to saturate with solution, not the nerve fibers emerging from the canal, rather the trunk of the infraorbital

nerve within the canal as far back as possible, the needle should be introduced into the canal as far as feasible, and the injection made under a certain amount of pressure. Merely approaching the foramen, as was customary heretofore, does not ensure the certain effect of the advanced canal injection. We therefore prefer Sicher's technique of

FIG. 107

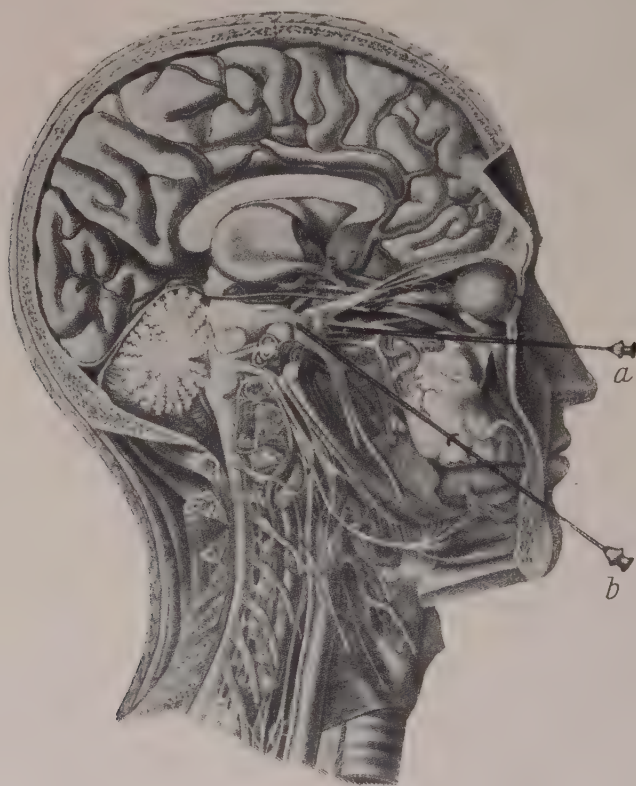


Injection at infraorbital foramen. (After Sicher.)

inserting the needle of 5 cm. length in the mucous fold close to the root apex of the central incisor (see Fig. 107) while palpating and covering the foramen itself with the index finger of the left hand. The needle is immediately directed toward the fixed point of the foramen, and the bone is reached in closest proximity of the aperture. As soon as the

palpating finger tip feels the needle hit the bone, a few drops are discharged, the field is once more carefully palpated, and the finger tip will then feel the needle enter the canal, into which it is further advanced while constantly injecting about 1 c.c. of solution. It is invariably

FIG. 108



Lateral view of cranium with nerves and needles in Gasserian ganglion. Needle *a* introduced orbitally by way of foramen rotundum; needle *b* in Gasserian ganglion by way of foramen ovale. (After Haertel.)

possible to proceed at least 10 mm. into the canal. When the needle once more meets with bony resistance, viz., the wall of the orbital canal, an additional 0.5 c.c. of solution is deposited. If the needle has advanced from 10 to 12 mm. in the canal without coming in contact with bone, it is advisable to stop because we may have to deal with a case in which

the canal is open toward the orbit after an unusually short distance. Such cases are rare, however, the average length of the closed portion of the canal measuring  $16\frac{1}{2}$  mm., according to Cieszynski. Anesthesia is complete after a waiting period of from five to seven minutes.

The risks of this injection are the same as with the older technique. The needle passes by the angular artery and the anterior facial vein, and may injure bloodvessels at the orifice of the canal (see Fig. 73).

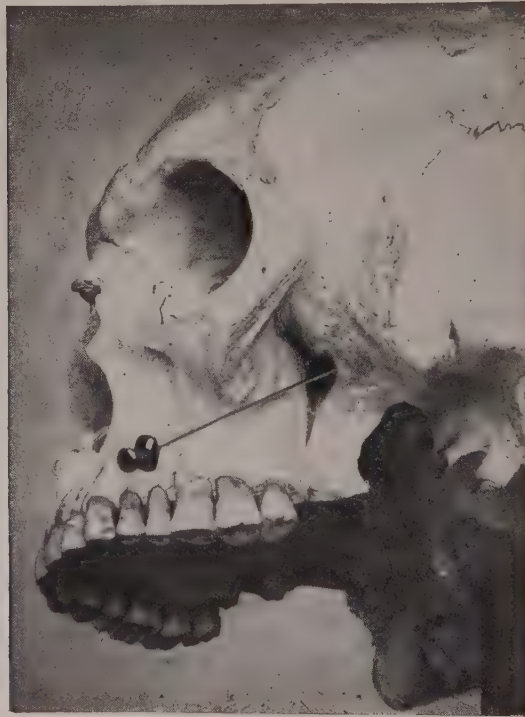
This method is indicated only in cases of acute abscess and in major operations, such as resection, when injection in the infraorbital foramina on either side is frequently called for. In simple cases, injection above the root apex of the canine (see Fig. 84) insures complete success; this injection, moreover, is easier to execute, and invariably and promptly effective. The needle is inserted at the root apex of the canine, and then advanced high up into the canine fossa, where from 0.5 to 1 c.c. of solution is deposited. Owing to the anastomosis from the opposite side, it is advisable to inject 1 c.c. of solution at the anterior nasal spine on the other side, unless one prefers infraorbital injection on both sides.

Palatally, the incisive (nasopalatine) and anterior palatine nerves may be blocked. If, however, the patient objects to the painful injection at the incisive foramen, as discussed in the paragraph on mucous anesthesia (p. 188), the palatal mucosa is infiltrated locally behind the front teeth. Within ten minutes the anterior teeth on the injected side are completely anesthetized.

*Extra-oral Blocking of the Maxillary Nerve.*—The intra-oral method of conduction anesthesia, as we have seen, is scientifically and technically practicable only under certain conditions, and is contraindicated in extensive inflammation when injections at the tuberosity or the infraorbital foramen cannot be safely executed. In order to avoid narcosis even in such cases, numerous dental operators have adopted the *extra-oral methods of injection* that had previously been employed in major surgery. While the value of these methods of extra-oral injection cannot be doubted, we must not overlook the fact that these injections are considerably more difficult than intra-oral injections, and require considerable greater knowledge, skill and care on the

operator's part. In dental practice extra-oral blocking is called for only in rare instances, hence it is more difficult to acquire the necessary experience which can hardly be gained from book descriptions only. The *dangers* connected with this method far exceed those of intra-oral injection, as the needle is advanced to the base of the cranium

FIG. 109



Blocking of the maxillary nerve in the pterygopalatine fossa. (After Matas-Braun.)

(see Fig. 109). The slightest neglect of the necessary precautions places the patient's life in serious jeopardy. Lack of sterility of solution or of asepsis in general may produce most serious complications to mention only retrobulbar phlegmon or purulent meningitis, either of which may terminate fatally.

The *maxillary nerve* can be blocked in all its branches shortly

after its exit from the foramen rotundum (see Fig. 53). Three routes lead to the spot where the solution is to be deposited:

1. Through the *orbit*, a distance of 5 cm. This route, however, is impractical owing to the close proximity of the eye.

2. At the *sphenopalatine fossa*, advancing the needle from the third molar along the tuberosity to a height of 3 cm. (see Fig. 101). By this method the nerve trunk is never reached directly; under most

FIG. 110



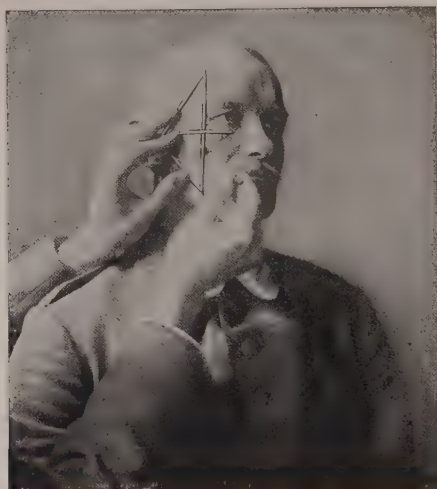
Injection in the pterygopalatine fossa. (After Haertel.) Right sphenoid bone and maxilla, posterior aspect. *a*, Correct position of needle in the foramen rotundum; *b*, incorrect position of needle in the orbit.

favorable conditions the solution will reach the nerve and the ganglion by way of diffusion.

3. In the *pterygopalatine fossa*, the direct route indicated by Matas. The needle is inserted at the inferior border of the zygomatic arch and advanced over the posterior aspect of the maxilla into the pterygopalatine fossa. This last method is the one most favorably indicated for dental purposes (see Fig. 109).

Regarding the *technique of extra-oral injection*, Rattel gives the following indications: "The superior margin of the zygomatic arch and the inferior border of the orbit are situated in one plane. If we draw a line vertical to this plane and tangent to the lateral margin of the orbit, and extend it downward until it intersects the inferior border of the zygomatic arch, then this point of intersection marks quite accurately the point of insertion of the needle." Rattel has constructed a simple device, consisting of two wires soldered together

FIG. 111

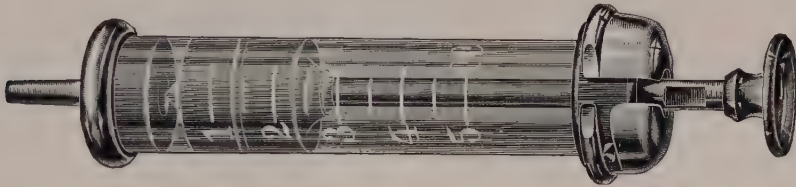


Wire guide applied to face to determine point of needle puncture. (After Rattel.)

to form a cross. The horizontal wire is held to the superior border of the zygomatic arch, and the inferior border of the orbit in such a way that the upper part of the vertical wire forms a tangent to the posterior margin of the orbit (see Fig. 111). At the intersection of the lower part of the vertical wire with the inferior border of the zygomatic arch lies the desired point for the needle puncture. The depth of insertion in the living is from 5 to 6 cm. Owing to the high location of the foramen rotundum, the needle is to be advanced with an upward inclination of about 30 degrees. Rattel recommends the following

procedure: The patient is requested to close the mouth lightly and to articulate the teeth without pressure, to avoid tenseness of the muscles. The wire guide is put in place, and the point of injection is marked. The field is disinfected with alcohol and ether, and fresh tincture of iodine is applied. The skin is pierced a few millimeters below the marked point with a short-bevelled needle of about 7 cm. length, and a small quantity of solution is discharged. Braun first makes a

FIG. 112



Record syringe for push-contact needles.

wheel with a very fine needle, and then inserts the 7-cm. needle. The needle is then inclined upward and backward at an angle of from 30 to 35 degrees and cautiously advanced until the maxillary tuberosity is felt. If the needle has been inserted too closely to the border of the zygoma it may be difficult to give it an upward inclination, and it should then be withdrawn and again inserted a little lower. The needle gently passes over the posterior aspect of the maxilla until suddenly at a depth of from 4.5 to 6 cm. the patient suddenly feels a

FIG. 113



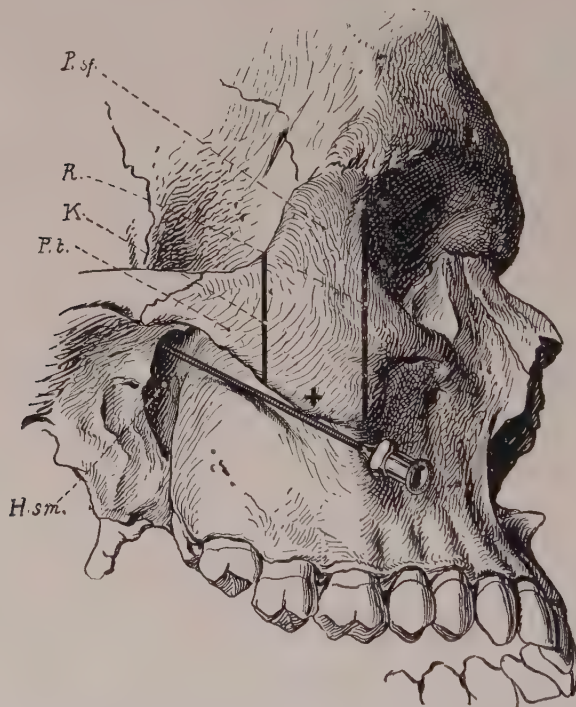
Needle for extra-oral injections.

*paresthesia* radiating to the cheek, the teeth and the nose. In most cases a bony resistance is felt at the same time. The Record syringe is now attached (see Fig. 112), and its contents emptied while slowly moving the needle back and forth. No pressure whatever is required, since the loose fatty tissue offers no resistance. The opening of the needle points upward.

Quite frequently—as Braun, among others, has pointed out—the

needle does not reach the pterygopalatine fossa directly, but hits the wing of the sphenoid bone. This is noted from the needle sliding quite unimpededly over the plane surface of this bone, especially dorsally. In these cases the needle point is directed anteriorly to avoid the obstacle. Suddenly the needle advances a little deeper past

FIG. 114



Injection in the pterygopalatine fossa. (After Sicher.) *H.sm.*, Sphenomaxillary hiatus; *K.*, guiding line of Kantorowicz; *R.*, guiding line of Rattel, which coincides with Braun's method; +, point of needle puncture used by Fischer; *P.sf.*, sphenofrontal process of zygoma; *P.t.*, temporal process of zygoma.

a smooth border, and the paresthesia appears. This is especially noticeable in male patients; for, according to Potterat, the maxillary nerve is situated immediately behind the insertion of the external pterygoid muscle, in man covered by a lamella of the greater wing of the sphenoid bone. If we have successfully passed this lamella the needle point can no longer deviate dorsally.

Sometimes a patient will exhibit a paresthesia when the needle has reached the maxillary tuberosity in a depth of from 2.5 to 3 cm. It is here where the posterior-superior alveolar branches enter the tuberosity. By a slight retraction and change in direction of the needle these branches can be avoided. This change in angle must not be considerable, lest failure result. If it is insufficient then the needle will not advance deeply enough, and the palatine nerves only are anesthetized. If it is too great then the needle may advance too

FIG. 115



Point of needle puncture XX for the extra-oral injection in the pterygopalatine fossa. (After Kantorowicz.)

far and enter the orbit through the fissure (see Fig. 110). This will affect the oculomotor and abducent nerves as evidenced by dilatation of the pupil and double vision. Entrance into the orbit is avoided by paying attention to the paresthesia, which always occurs as the needle passes the fissure.

It is of great importance closely to observe these *paresthesias*. "Seeking the nerve trunks with the point of the needle is easy and certain when the position of the nerve can be definitely located in connection with bony landmarks, which aid in the guidance of the

needle. It is much more difficult when these landmarks are absent and the nerve is situated in the midst of thick soft parts. A good guide in all cases is the radiation of sensations of paresthesia toward the periphery, which occurs following the irritation of the nerve with the needle. If possible, the patient must be instructed in this regard before the introduction of the needle, and must be told to speak at once as soon as he notices the paresthesia. If these sensations occur it is certain that the point of the needle is in the proper place." (Braun.) Diffusion of anesthetic solution through the fissure is unavoidable.

FIG. 116



Injection into the pterygopalatine fossa. The mandible is firmly held by thumb and three fingers. The index finger is pressed down as far as possible on the relaxed masseter muscle below the zygomatic arch and in front of the ascending ramus of the mandible. Introduction of the needle at finger nail. Direction toward the middle of the inferior border of the orbit. (Kantorowicz.)

The resulting ocular phenomena are of short duration and of little importance. From 2 to 5 c.c. of a 2 per cent. novocain-suprarenin solution are injected with a Record syringe, which is attached after the 7-cm. needle is in place (see Figs. 112 and 113).

The waiting period is from twenty to thirty minutes. Complete anesthesia of the area supplied by the maxillary nerve ensues, excepting a slight sensation in the incisor region, due to the anastomoses from the other side which are eliminated by a local injection at the anterior nasal spine.

Extra-oral (basal) nerve blocking is *indicated* in resections of the maxilla, acute purulent inflammations, tumefactions or fractures of the maxilla and tumors in the area supplied by the second division. This injection should never be made without absolute assurance of asepsis and sterility of solution; for even with all precautions, the *secondary phenomena* of this form of anesthesia are not without danger. In 300 injections Rattel noted: Fainting of short duration, 3 cases; vertigo, 10; facial pallor, 2; edema and blanching of the lower eyelid, 9; double vision due to diffusion of solution into the orbit, 15; dilatation of the pupil, 5; atonia of the upper eyelid, 1; sensation of heat in the eye, 2; scintillation in the eye, 5. All these secondary phenomena disappear completely after absorption of the solution.

Occasionally even intra-oral tuberosity injections are followed by an egg-shaped *edema* of the cheek. This consists in a swelling of the adipose tissue lying between the masseter, buccinator and posterior wall of the tuberosity, and is caused by an injury to one of the numerous veins within this interstitial fatty tissue or to the posterior-superior alveolar artery, leading to the formation of an *hematoma* (see Figs. 73 and 101). Hematomata, which at times cause severe after-pain, disappear within two or three days upon application of wet and warm compresses and internal doses of pyramidon.

A somewhat different method of injection is recommended by Sicher: "The angle between zygoma and maxilla on one side, and the angle at the superior margin of the zygomatic arch between its horizontal and vertical process on the other side are palpated and projected to the lower border of the zygomatic arch. It is halfway between these two points where the needle is inserted and advanced inward and slightly backward and upward (see Fig. 114). At a depth of about 3 cm. it hits the posterior wall of the maxilla, *viz.*, the maxillary tuberosity, where a few drops of solution are discharged to render painless the further progress of the needle over the bone. After sliding over the tuberosity, contact with the bone is presently lost and the needle enters the pterygopalatine fossa at a depth of from 5 to 6 cm., as evidenced by paresthesia affecting the gums only if the needle has reached about the center of the fossa, but affecting teeth, lips and cheek

if the upper portion of the pterygopalatine fossa is reached, depending upon the angle of upward inclination of the needle.

If the maxillary tuberosity is especially well developed, the needle may, even with this method, be deviated behind the sphenomaxillary hiatus and may hit the lateral lamella of the pterygoid process. This is noted from: (1) The non-appearance of paresthesia; (2) the fact that the needle, instead of being fixed in the narrow fossa, easily slides back along the smooth bony surface. It should then be withdrawn slightly and again advanced in a more outward direction until it is plainly felt to enter the fossa (see Fig. 110).

The *waiting period*, until establishment of profound anesthesia depends upon the spot where the needle hits the pterygopalatine fossa, which, with the method described, usually is at the posterior wall. The higher this spot is situated, the more closely we get to the foramen rotundum and the nerve trunk, hence the more rapidly anesthesia ensues. At the same time, there is greater likelihood of diffusion of solution through the superior or inferior orbital fissure, which is of no consequence as far as the anesthesia is concerned, but produces brief paralysis of the nerves supplying the eye muscles manifested in the form of double vision. It is, therefore, preferable to incline the needle but slightly above horizontal. This necessitates injecting a greater amount of solution into the pterygopalatine fossa (from 3 to 4 c.c.), and allowing a longer waiting period (up to fifteen minutes), but does almost completely away with the alarming, though harmless secondary phenomena."

Lindemann also has made a large number of extra-oral injections, preferring the orbital route. He aims to reach the maxillary nerve trunk at the foramen rotundum by going through the orbital fissure. On its way through the fissure, however, the needle may deviate into the orbital cavity as well as into the fossa behind the maxilla, which is immediately noted by a lessened tissue resistance. The needle should then be withdrawn at once and introduced again in an altered direction.

Our experience induces us to give preference to the injection from the lower border of the zygomatic arch. This method, which is favored also by Kantorowicz, may once more be briefly described:

With the patient's mouth lightly closed, the contour of the zygomatic arch is carefully palpated, and the nearly right angle formed by the arch and the superior border of the orbit is determined (see Fig. 115). From this point a line is drawn vertically downward; its intersection with the inferior border of the zygomatic arch marks the point for insertion of the needle.

The 7-cm. needle is introduced into the skin somewhat below this point (about 0.5 cm.) with a slightly upward inclination, the Record syringe is attached and a few drops of 2 per cent. novocain-suprarenin solution are discharged (see Fig. 116). The needle is then advanced to a depth of from 2 to 3 cm. without meeting with resistance, until it hits bone, *viz.*, the maxillary tuberosity in about the region where the posterior-superior alveolar nerves enter this bone. If 2 c.c. of solution are deposited at this spot the molars alone are anesthetized. To produce anesthesia of one-half the maxilla, the needle must be advanced further in a backward and upward direction to the level of the orbital border. After further penetrating from 2 to 3 cm. it once more meets hard resistance, *viz.*, the floor of the pterygopalatine fossa, where from 2 to 3 c.c. of solution are injected.

If the needle reaches the immediate vicinity of the nerve the anesthesia is rapid and profound. If it is introduced at a right angle to the cheek it reaches the pterygopalatine fossa 1.5 cm. below the sphenopalatine ganglion, and complete anesthesia is established by way of diffusion within from ten to fifteen minutes. If, on the other hand, the needle has been inserted obliquely upward to the level of the orbital border, then the solution is deposited closely to the nerve trunk, and anesthesia ensues within a few minutes.

*Failures*, according to Kantorowicz, may result from:

1. Anatomic obstacles. Occasionally, the mandible is so strongly developed that access through the sigmoid notch is blocked. When the mouth is slightly opened the desired passage-way will usually become free.

2. Incomplete anesthesia. Incomplete anesthesia of the anterior teeth is due to insufficient upward inclination of the needle. Since the trunk of the second division lies approximately on a level with the orbital floor, the needle must be advanced in that direction.

The initial needle puncture is made by pressing the index finger down as far as possible on the relaxed masseter muscle below the zygomatic arch and in front of the ascending ramus of the mandible, and introducing the needle above the finger-nail (see Fig. 116).

Once more, the difficulties and complications of this method should be emphasized. Any operator who is in the least uncertain regarding absolute asepsis, or who occasionally experiences swelling, bleeding or after-pain from ordinary injections, should leave this method severely alone.

**Injection at the Inferior Dental or Mandibular Foramen (Mandibular Injection).—***The Inferior Dental or Mandibular Foramen.*—The inferior dental or mandibular foramen, situated in the internal surface of the ascending ramus, permits the passage of the inferior dental nerve, which, with the inferior dental artery, passes forward within the dental canal in the mandible as far as the mental foramen, where it divides into two branches, one incisor, running within the bone of the incisor teeth; the other mental, passing through the mental foramen to the outer surface of the mandible and terminating in the soft tissues of the chin and lip. In the technique of injection at the mandibular foramen, certain important anatomic features must be duly considered, and for this reason a few topographic details will be briefly described.

The body of the mandible is not continuous in a horizontal straight line with the ascending ramus but presents a lateral deviation at the angle, so that the internal surface of the ascending ramus is not parallel with the lingual surface of the body of the jaw (see Figs. 41, 92 and 97). The rami spread posteriorly (see Figs. 43, 44, 92 and 117); therefore, if the vicinity of the mandibular foramen is to be reached, we must never advance posteriorly parallel with the dental arch (see Figs. 117 and 118), but at an acute angle to the dental arch (see Figs. 43 and 117). If the direction of the ascending ramus is projected anteriorly, the line of projection will intersect the opposite side of the mandible, approximately in the region of the canine (see Figs. 43, 44 and 117). Hence, in order to reach the vicinity of the inferior dental foramen, the syringe will usually come to lie over the canine

region of the opposite side (see Fig. 104). This valuable landmark enables one to reach with accuracy the mandibular sulcus occupied by loose connective tissue, which has a great avidity for the anesthetic solution (see Fig. 119).

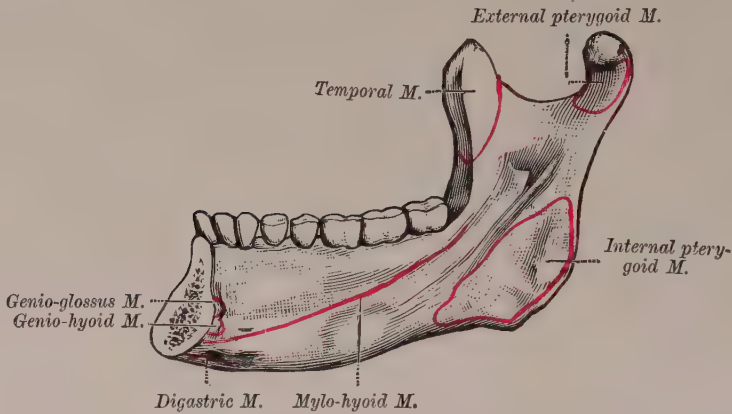
FIG. 117



Position of the syringe for injection at mandibular foramen: 1x, external oblique line; 2x, retro-molar fossa; 3x, internal oblique line; 4, mandibular foramen behind lingula; 5, incorrect position of the syringe, parallel to the teeth.

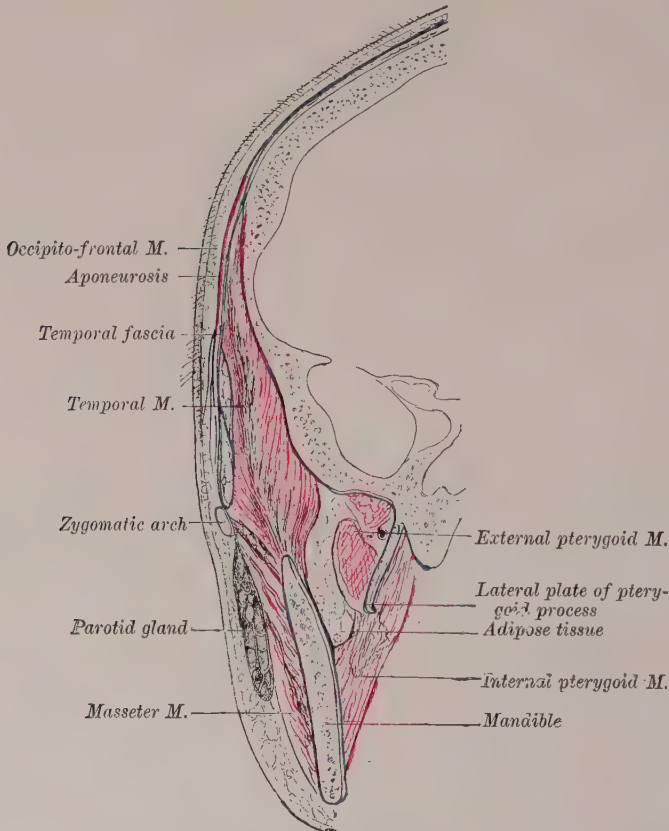
**Topography of the Ascending Ramus.**—Starting with the conditions as they present themselves in the living, we shall first study the diagram in Fig. 120. The posterior limit of the dental arches is marked by the upper and lower right third molars. The lateral boundary of the isthmus of the fauces is indicated at *a* (anterior pillar of the fauces). Laterally we note, ascending from the lower third molar, a

FIG. 118



Origins and insertions of muscles upon inner surface of the mandible. (From Rauber and Kopsch.)

FIG. 119



Frontal section through temporal region. The black line indicates the aponeurosis, the blue line the periosteum and temporal fascia. (From Merkel.) At the mandibular foramen a mass of adipose tissue is observed which offers no resistance to the advance of the needle. (*Mandibular sulcus*.)

well-defined mucous fold *b*, which may be fittingly called the *molar fold*. At *c* x the spot is marked where the needle is to be inserted for mandibular injection. *f* indicates the palpating finger-tip, which is in contact with the ascending ramus.

FIG. 120

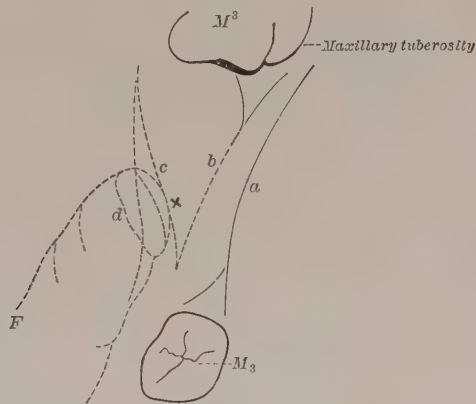


Diagram showing the mucous folds in the region of the retromolar triangle.

FIG. 121

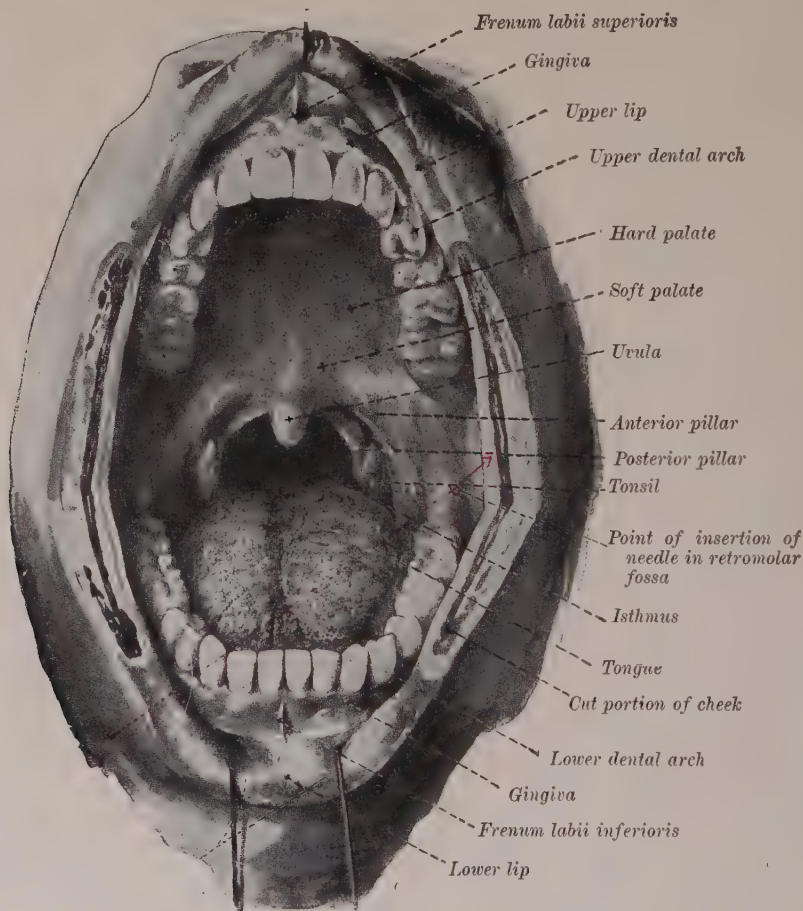


View into the oral cavity, with point of insertion of the needle for mandibular anesthesia (white spot). The point of insertion lies about 1 cm. above, and laterally of, the last molar.

Fig. 121 is a photograph of this region in the living. Across the dorsum of the tongue we look into the isthmus of the fauces, the anterior and lateral boundary of which, viz., the anterior pillar of the

fauces, appears as a small fold. Immediately laterally and slightly anteriorly, the broader and bulkier *molar fold* is plainly seen. At its anterior border a white point marks the place of insertion of the needle for mandibular anesthesia (see also Fig. 122).

FIG. 122

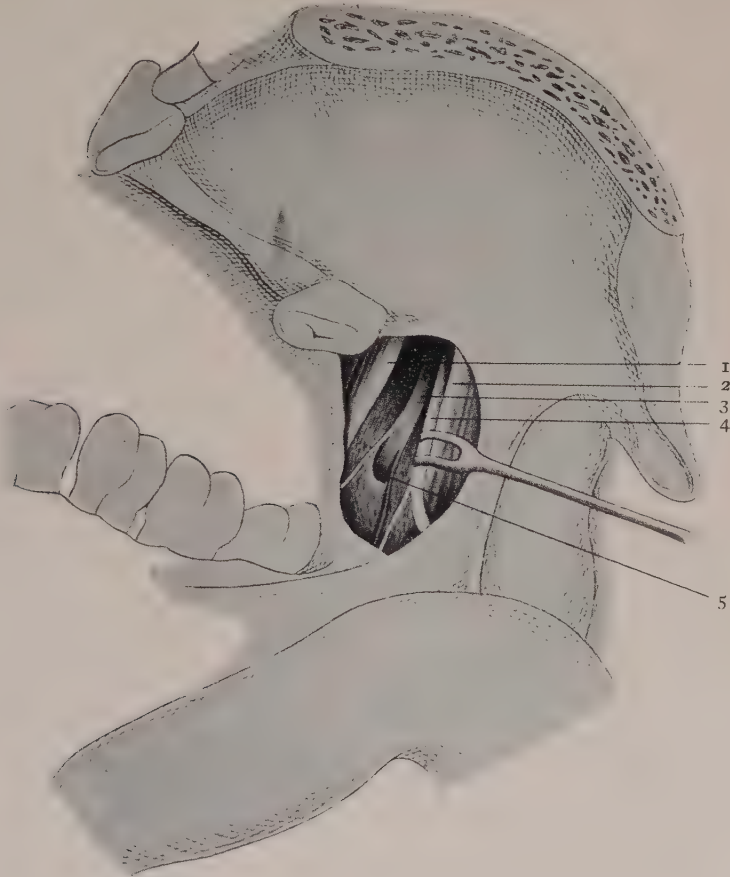


Oral cavity cut widely open. The dotted red line indicates the correct position of the syringe for mandibular anesthesia. (After Spalteholz.)

These landmarks are all that is to be recognized with the eye by way of orientation. The folds vary a great deal in appearance, least

of them the anterior pillar of the fauces, so that, in obscure cases, this furnishes a valuable guide. A very important indication for finding the place of injection is furnished by the plainly palpable anterior border of the ascending ramus, which lies buccally of the place of

FIG. 123



View into the mandibular sulcus. (Gasser.) 1, Temporal muscle; 2, internal pterygoid muscle; 3, inferior alveolar nerve; 4, lingual nerve; 5, mandibular foramen.

injection as shown in Fig. 116. After this spot has been located correctly the needle is simply advanced upon the internal surface of the ascending ramus.

Fig. 123 shows an anatomic specimen, partly in diagram.

The right side of the oral cavity is exposed by median section. The distorted tongue is deflected downward. The picture is best studied by beginning from the tonsil shown below the retractor, which is situated between the anterior and posterior pillars of the fauces. In front of the latter the molar fold is very clearly seen extending from the last lower molar palatally toward the corresponding upper tooth. Anteriorly to this fold, a long incision is made through the place for the insertion of the needle indicated in Fig. 121, exposing the structures illustrated in Fig. 123. The parts surrounding the dissected area are indicated diagrammatically. The incised mucosa has been widely drawn apart, so that the way to the very spot where the injection is made is plainly seen. Together with the mucosa, the buccinator muscle, which in this locality is thin and therefore not prominent, is cut through, affording a view into the anterior part of the space termed *pterygoid fissure* or *pterygomandibular space*.

The inner surface of the mandible with the mandibular foramen, through which the mandibular nerve enters the mandibular canal, is clearly shown (see also Figs. 41, 42 and 117). In front we note the tendon of the temporal muscle running along the anterior border of the ascending ramus; in back the anterior portion of the internal pterygoid muscle.

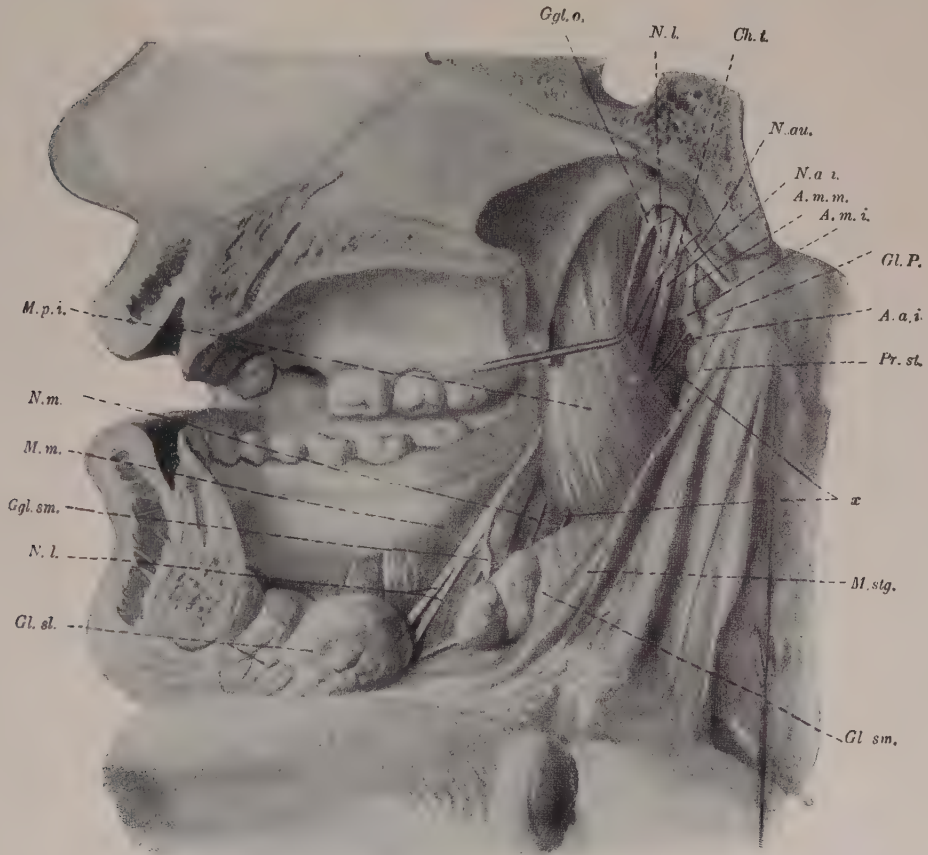
Before entering the mandibular canal the mandibular nerve gives off two smaller branches: One, anterior, supplying the mucosa at the posterior teeth, the *long buccal nerve*, one posterior, or *mylohyoid nerve*.

The *lingual nerve* also is seen slightly retracted; still, its situation in close proximity to the mandibular nerve is apparent. The details of the relative positions of these two nerves are seen in the subsequent illustrations (see Figs. 124 and 125). A small quantity of loose connective tissue, which posteriorly assumes a more adipose character, has been removed from the area under discussion.

Fig. 58, which appears on page 156, gives a general view of the course of the *mandibular* and *lingual nerves* (see also Figs. 54 and 59). In Fig. 58 a portion of the ascending ramus is removed and the mandibular canal is laid open. Between the two pterygoid muscles which

form the pterygoid fissure, the lingual nerve runs forward to the floor of the mouth, the mandibular nerve downward into the body of the mandible; anteriorly the mandibular nerve is seen emerging from the mental foramen.

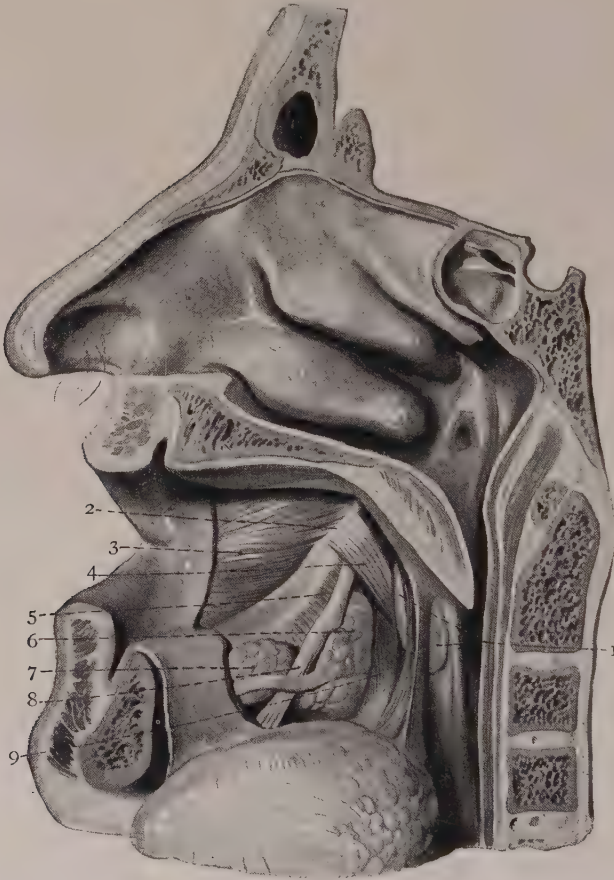
FIG. 124



Internal aspect of infratemporal region after extra-oral introduction of needle. (After Sicher.)  
*A. a. i.*, Inferior dental artery; *A. m. m.*, middle meningeal artery; *Ggl. o.*, otic ganglion; *Gl. P.*, parotid gland; *Gl. sm.*, submaxillary gland; *M. p. i.*, internal pterygoid muscle; *N. a. i.*, inferior dental nerve; *N. l.*, lingual nerve (considerably stretched by downward traction of tongue); *N. m.*, mylohyoid nerve; *x*, needle; *A. m. i.*, internal maxillary artery; *Ch. t.*, chorda tympani nerve; *Ggl. sm.*, submaxillary ganglion; *Gl. sl.*, sublingual gland; *M. m.*, mylohyoid muscle; *M. stg.*, styloglossus muscle; *N. au.*, auriculotemporal nerve; *Pr. st.*, stylohyoid process.

By removing the internal pterygoid muscle the course of the mandibular nerve to the mandibular foramen is exposed. At the same time we note the *mylohyoid nerve*; the distribution in the tongue

FIG. 125

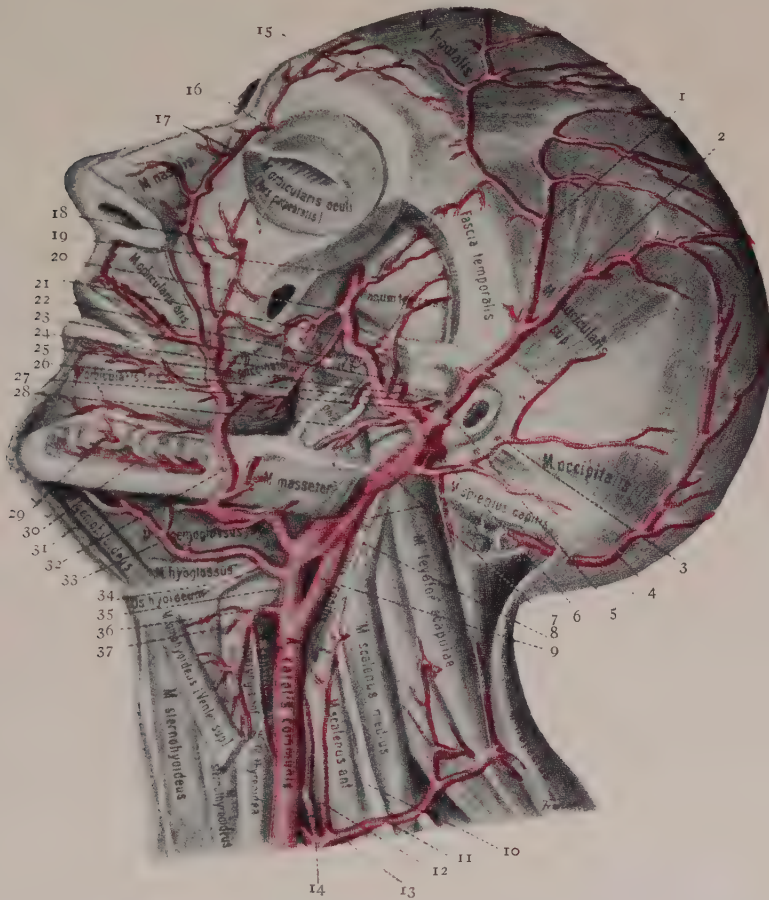


Muscles of cheeks and pharynx. 1, Palatine tonsil; 2, pterygomandibular raphe; 3, buccinator muscle; 4, buccopharyngeal and mylopharyngeal muscles; 5, mylohyoid muscle; 6, submaxillary ganglion; 7, sublingual gland; 8, lingual nerve; 9, styloglossus muscle.

and floor of the mouth of the *lingual nerve* with its submaxillary ganglion; the hypoglossal nerve ascending from below; the submaxillary gland with its duct and the sublingual gland (see Fig. 125).

To insure an accurate topographic orientation, three sections through the mandibular region on various levels of the ascending

FIG. 126



The deep branches of the external carotid artery. 1, Frontal branch; 2, parietal branch; 3, posterior auricular artery; 4, occipital artery; 5, superficial temporal artery; 6, internal maxillary artery; 7, external carotid artery; 8, occipital artery; 9, internal carotid artery; 10, brachial plexus; 11, superficial cervical artery; 12, ascending cervical artery; 13, inferior thyroid artery; 14, thyrocervical trunk; 15, supraorbital artery; 16, frontal artery; 17, dorsal nasal artery; 18, infraorbital artery; 19, anterior prot. temporal artery; 20, posterior-superior alveolar artery; 21, buccinator artery; 22, pterygoid branches; 23, posterior prot. temporal artery; 24, pterygoid branch; 25, middle meningeal artery; 26, anterior tympanic artery; 27, prot. auricular artery; 28, inferior alveolar artery; 29, mental artery; 30, inferior alveolar artery; 31, mylohyoid muscle; 32, external maxillary artery; 33, lingual artery; 34, hyoid branch of lingual artery; 35, superior laryngeal nerve; 36, superior thyroid artery; 37, superior laryngeal artery.

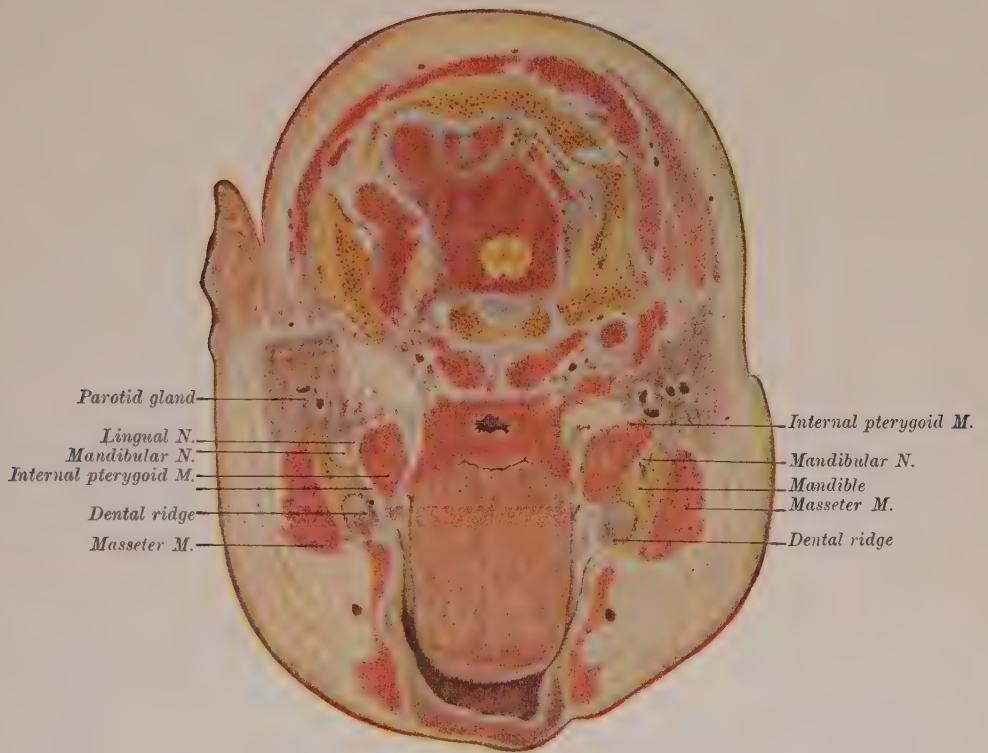
ramus are reproduced (see Plates I and II, and Fig. 127). Plates I and II are vertical microscopic sections, Fig. 127 is a horizontal frozen section through infant heads.

In Plate I the section goes through the posterior portion of the ascending ramus, past the anterior border of the condyloid process. The bloodvessels have been injected to facilitate visualization of their arrangement; the nerves are marked in yellow. Of special interest is the space between the two pterygoid muscles on the internal surface of the mandible. In this space are seen the internal maxillary artery and branches thereof, the mandibular nerve and the lingual nerve. It is important to note that in the posterior part of the pterygomandibular space these parts are embedded in loose, partly adipose connective tissue, and that this space, which is so important in conduction anesthesia, broadens here considerably. This extension of interstitial tissue, as may be seen in Fig. 128, is situated between the two pterygoid muscles, and is the greater the more closely we approach the posterior border of the ascending ramus. The mandibular nerve (n. alveolar. inf. in Plate I), presents a slight curvature anteriorly as it is about to enter the mandibular canal. The proximity of the *internal maxillary artery* cautions us not to advance the needle too deeply into this space.

Most instructive is a comparison with Plate II, in which the section is made more anteriorly through the ascending ramus directly through the mandibular foramen. The lingula appears as a marked projection covering the entrance to the mandibular canal and protecting the mandibular nerve.

The pterygomandibular space here is considerably narrower, owing to the internal pterygoid muscle being in closer contact with the mandible. From the foregoing it appears that, in order to reach the mandibular nerve, the needle must be kept in close contact with the bone, and that the conditions are more favorable at a height of about the middle of the ascending ramus than lower (see Fig. 120). Furthermore, it is evident that the mandibular nerve cannot be reached in the mandibular foramen, because it is safely covered by the lingula, but before it reaches the foramen, *viz.*, in the pterygo-

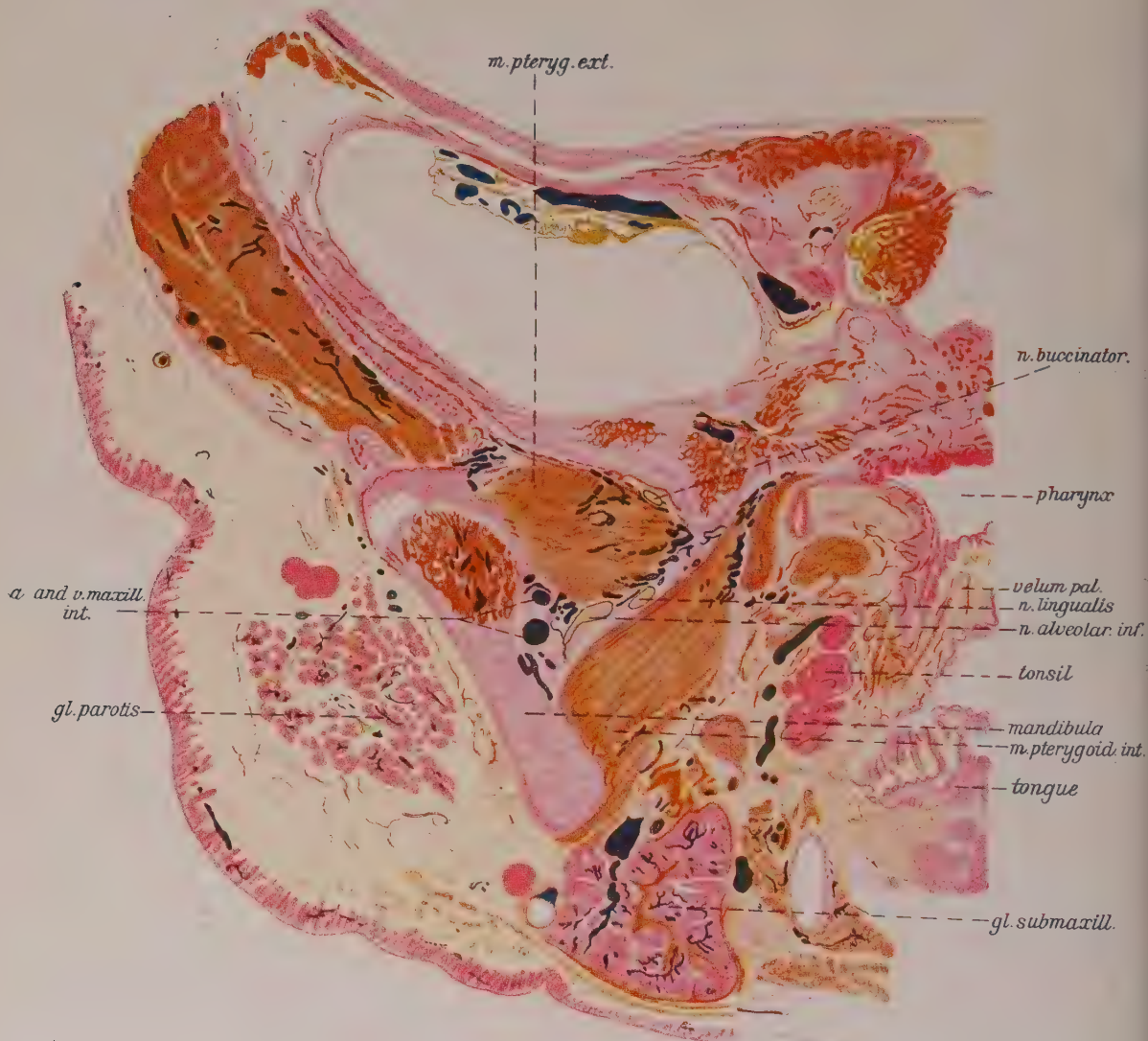
FIG. 127



Horizontal section through mandibular foramen in infant head. (Gasser.)







Vertical Microscopic Section through Posterior Portion of Ascending Ramus in Infant Head.



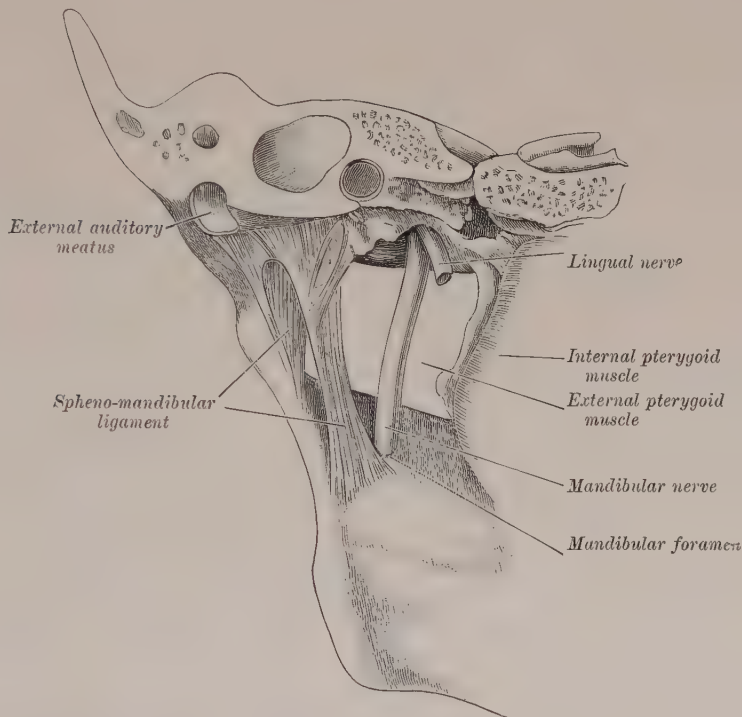
Vertical Microscopic Section through Mandibular Foramen  
in Infant Head.



mandibular space where infiltration is greatly favored by the loose connective tissue investing the nerve.

In Fig. 123 the manner in which the lingula is covered by the pterygomandibular ligament is beautifully shown. This ligament is of great advantage for the management of the needle in injecting, because it effectually protects the muscles.

FIG. 128

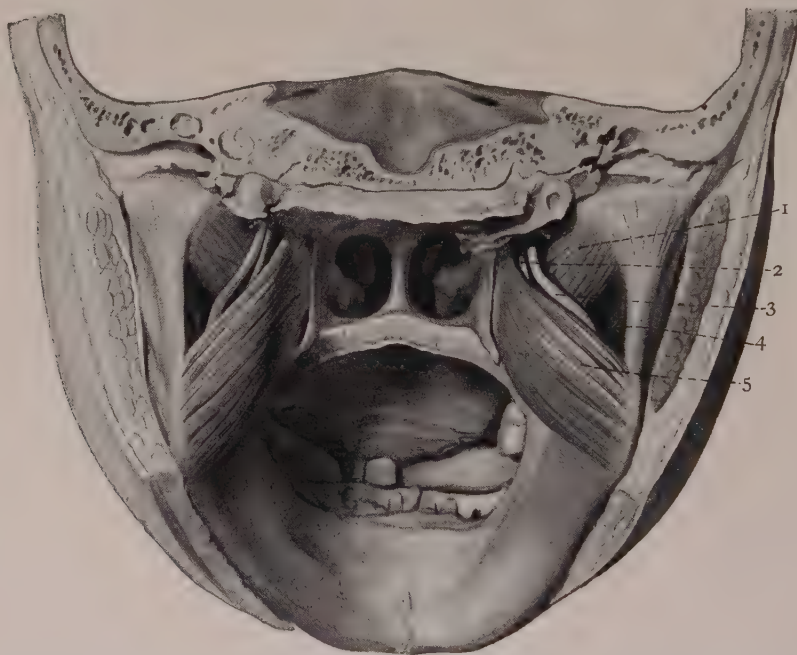


The sphenomandibular ligament is inserted at the lingula, which it covers completely. (Henle.)

In order to determine the local relationships of the parts, it is most desirable to compare two sections made perpendicularly to one another, as one section merely shows the arrangement of the parts in one plane. For this reason, Fig. 127 has been inserted, which is a horizontal section through the same region. The section is made through the commissures of the lips antero-posteriorly in a slightly

ascending plane, so as to go through about the middle of the ascending ramus. By a fortunate chance, the section passed through the mandible at slightly different levels, on the left side somewhat deeper and directly through the orifice of the mandibular foramen, on the right side a little above that orifice.

FIG. 129



Pterygomandibular space, seen postero-anteriorly. (Sicher.) 1, External pterygoid muscle; 2, internal pterygoid muscle; 3, pterygomandibular space; 4, inferior dental nerve; 5, lingual nerve.

The parts are recognized by the position of the tongue, with the intersected soft palate and the lumen of the pharynx. On each side we note the mandible with the two projections at the anterior border of the ascending ramus, the point of insertion of the temporal muscle and the buccinator crest; on the outer side the masseter muscle; on the inner the internal pterygoid muscle; back of the mandible the parotid gland.

By comparing the two sides it is again seen that in the anterior

portion of the mandible (left side of Fig. 127), the passage of the needle is narrowed by the closeness of the internal pterygoid muscle to the bone, while a little farther posteriorly and above (right side of Fig. 127) the road is free, because the muscle lies farther away from the bone, leaving a broad space occupied by adipose connective tissue in which the mandibular nerve is embedded before its entrance into the mandibular foramen; this space is the correct place for infiltration.

In addition, Plates I and II and Fig. 127 give a clear idea of the local relationship of the lingual nerve to the mandibular nerve in the pterygomandibular space. The lingual nerve runs a little more mesially, viz., at a greater distance from the bone, still closely enough to render it highly probable that both nerves are reached by infiltration, though the mandibular nerve will be affected more directly.

**Technique of Injection for Mandibular Anesthesia.**—In the technique of mandibular anesthesia the following preliminary observations are important:

In the widely opened mouth the mucous folds which, as we have seen, are of such vital importance for a successful injection, are not recognized at first glance. In front of the tonsil we note a well-defined fold, the anterior pillar of the fauces descending from the soft palate. Mesially and anteriorly another fold is seen running in the direction of the dental arch. Starting on the inner lingual side the *internal oblique line*, then the *external oblique line*, are palpated and the tip of the finger is firmly fixed in the bony groove between these two lines, whereupon a groove or depression in the mucous membrane becomes noticeable. This corresponds to the underlying trigonum retromolare or *retromolar triangle*, so termed by Braun. Converging with the fold *c*, the molar fold *b* runs downward; it is between *b* and *c*, yet more closely to *c*, that the needle must be inserted for mandibular anesthesia (see Fig. 120).

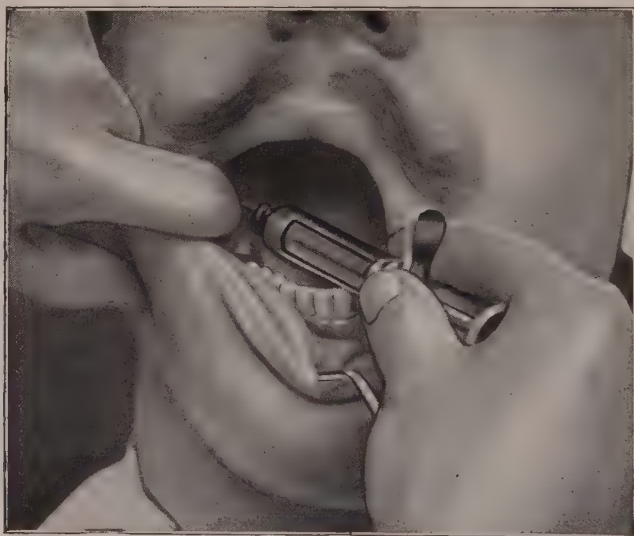
When the mouth is wide open the molar fold, owing to its hardness and size, may be mistaken for the internal oblique line. Sicher, therefore, recommends fixing first the external oblique line by sliding the palpating finger-tip along the line of reflection to the anterior border of the ascending ramus. From here the finger-tip palpates

across the retromolar triangle to the internal oblique line, from behind which and farther inward the pterygomandibular fold is noted.

Our method of procedure, then, is as follows:

The patient is requested to hold the head straight with a slight backward inclination, so that the lower teeth are presented in a horizontal plane. The mouth is wide open. With the index finger of the left or free hand, we palpate the anterior border of the ascending ramus, advancing in the mucous fold mesio-distally, until the external

FIG. 130



Position of syringe for injection in mandibular foramen and palpation of retromolar triangle.  
The syringe is held like a penholder.

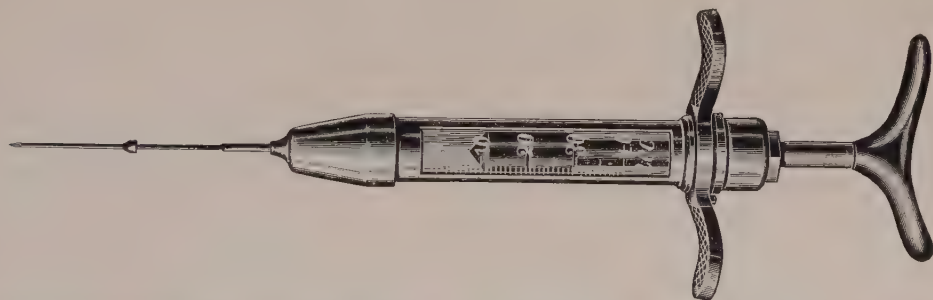
oblique line is reached. The finger-tip then swings inward, and the finger-nail firmly fixes the internal oblique line which lies somewhat posteriorly. The finger then rests upon the masticating surfaces of the molar teeth, its tip lies within the retromolar triangle, the nail points inward. After very little practice, the finger-tip will find this triangle immediately and fix the internal oblique line without difficulty.

This portion of the ascending ramus presents great variations, due to individual peculiarities, age, etc. In the edentulous the relation-

ship between external and internal oblique lines, and the retromolar triangle are not clearly defined, and the needle puncture is more difficult. Nevertheless, the triangle can be palpated even in these cases, as a shallow indentation, and the proper spot for the injection determined.

The needle is inserted in the mucosa at the middle of the fingernail, close to the border of the internal oblique line (see Fig. 130), and, with the syringe, supported by the teeth of the opposite side in about the canine region, is advanced horizontally backward on the inner surface of the ascending ramus (see Figs. 117 and 118). The needle-point shortly after insertion should touch the bone; otherwise it should

FIG. 131



Syringe with safety needle for mandibular injection. The needle can be inserted only to the marking disk.

be withdrawn and reinserted more closely to the bone. As it advances, it is plainly felt sliding over the bony crest. In order to reach the sulcus, the syringe may have to be moved further distally on the opposite side in cases where the crest is so strongly developed as to prevent the further advance of the needle. Not more than 1.5 cm. of the needle should disappear in the mucosa (see Fig. 131), lest it advances too far, and the proper place for deposition of the solution be missed. The syringe is best mounted with the long needle No. 2, which has a marking disk at about its middle, leaving the other half of the needle protruding, and preventing untoward results from breaking of the needle. On its entire way to the sulcus the needle should be in close contact with the bone.

The internal oblique line, which is important in this connection, varies greatly in different individuals, and is sometimes so strongly developed that it causes difficulties in the introduction of the needle. In such cases the needle is inserted a little more lingually, and the syringe is advanced still further from the opposite side until one succeeds in passing this bony ridge and reaching the mandibular sulcus. As the needle slowly advances, some solution is discharged and when the proper depth is reached the bulk of the solution is discharged.

The point of insertion of the needle usually lies about 1 cm. above the level of the masticating surfaces of the molars; in children and young persons level with them; in old persons higher up.

The technique of this form of injection offers some difficulties, which, however, with some practice are easily overcome. If the correct level for the insertion of the needle has been found, then the mandibular sulcus is reached just above the lingula (see Figs. 44 and 117). The distance from the anterior margin of the internal oblique line to the posterior border of the lingula is about 15 mm. During the injection it is best to rest the syringe barrel on the canine region of the opposite side, thus securing a certain support for the syringe and a guide for the correct level for the insertion of the needle (see Figs. 43, 44, 117, 128, 130).

*Management of the Needle.*—The needle passes over the bone without puncturing the periosteum. A certain touch is soon acquired as to whether the needle is advancing close to the bone. If, in case of a very sharp angle of the bone, the periosteum is felt to offer resistance, no matter how slight, the needle should not be advanced any farther, and under no condition by force, else the needle may become fixed in the bone. It is best to withdraw the needle carefully for a short distance, and, after slightly altering its direction, to make a new attempt at introduction. During the first insertion of the needle the syringe frequently lies almost in the direction of the dental arch, but must presently be moved over to the opposite side as it advances at the internal border of the bone.

*Injection of the Solution.*—The solution should be discharged very slowly and carefully, beginning immediately after insertion of

the needle, in order to anesthetize simultaneously the *lingual nerve*, which descends in front of the mandibular nerve (See Figs. 58 and 59). The adipose and loose connective tissues occupying the pterygomandibular space readily absorb the solution without any pain to the patient. Infiltration of the muscles in this region is out of the question,

FIG. 132



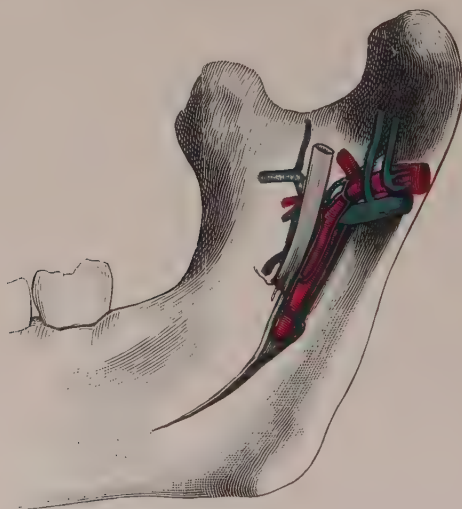
Position of the syringe during injection at the mandibular foramen. The finger of the left hand rests in the retromolar triangle.

as has been shown before; nor is there any danger of puncturing the artery with its venous plexus, which has sufficient space to escape into the loose surrounding tissues or the fundus of the inferior dental canal (see Fig. 133).

Usually 2 c.c. of a 2 per cent. novocain-suprarenin solution are injected; twice that quantity, however, may be used with impunity.

The injection on the left side of the mandible offers somewhat greater difficulties. While on the right side the retromolar triangle is palpated with the left hand, and the injection is made with the right, it is advisable to use the left hand for injection on the left side, according to Peckert's suggestion, and to palpate and fix the retromolar triangle with the right. Practice will soon determine for every operator the technically best method of executing the injection.

FIG. 133



Nerves and bloodvessels at the mandibular foramen. (After Zuckerkandl and Scheff.)

*Effect of the Injection.*—About three minutes after the injection the patient perceives a slight tingling in the lip and tongue on the injected side. This tingling or pricking is the best indication that the injection has been correctly made. This sensation gradually increases, and a certain numbness of the entire half of the jaw ensues, so that the contact of the rinsing glass with the anesthetized lip is no longer felt. The patients have a feeling as if the rim of the glass had been cut away in semilunar shape. The lip on the anesthetized side droops slightly, and exhibits symptoms of partial paralysis; the patient usually feels as if it were greatly swollen. A sensation of warmth may be perceived over the entire anesthetized area. Difficulty in deglutition

or ankylosis is absent if the technique has been correct; its presence indicates that the injection has been made into the muscles and not close enough to the bone. The anesthesia persists for about one hour and then subsides gradually, normal sensation returning after about three hours.

When indicated, no hesitancy need be felt about injecting at the mandibular foramen on each side at one sitting. The results of this double injection are surprisingly favorable, and no untoward sequelæ, alarming symptoms of paralysis or tongue-biting will occur if the patients are instructed to be cautious in talking and refrain from eating until normal sensation has returned.

Mandibular injection alone does not produce complete anesthesia of the mandibular half. The molars, and the second and first bicuspid, to be sure, are fully anesthetized, but the canine and incisors, owing to the anastomoses from the opposite side, exhibit merely reduced sensibility. The lingual mucosa becomes anesthetized only if the lingual nerve has been blocked simultaneously with the mandibular, which is usually the case. The buccal mucosa, however, in the region of the first and second molars and second bicuspid remains sensitive, thus necessitating for the purpose of surgical intervention the special elimination of the *buccinator* or *long buccal nerve*.

**Injection at the Mental Foramen.**—The lower bicuspid are best anesthetized by a mandibular injection, although a correctly executed injection at the *mental foramen* often gives satisfactory results. The mental foramen is palpated on the outside, being located between first and second bicuspid, its orifice pointing distally. By way of a landmark, a line may be drawn from the center of the pupil of the eye through the corner of the mouth. This line passes almost exactly through the infraorbital foramen, its prolongation through the mental foramen. While the index finger of the free hand fixes the foramen, and the thumb retracts the lower lip, the needle is inserted in the mucous fold between first and second bicuspid and advanced a very short distance in a distal direction and pointing toward the bone, so as to make sure that the solution is deposited directly over the orifice of the foramen. One cubic centimeter of a 2 per cent.

novocain-suprarenin solution is injected and diffusion into the canal is hastened by gentle massage over the region. It is absolutely necessary to keep the needle in constant contact with the bone, else the superficial branches only of the inferior dental nerve will be blocked, and the lip and soft tissues covering the chin, but not the teeth, will be anesthetized. For surgical intervention the lingual gingiva has to be additionally infiltrated. As this injection is interfered with by the copious discharge of saliva from the sublingual gland, mental injection is best limited for strictly dental operations, such as pulp extirpation, excavation of hypersensitive dentin, etc.

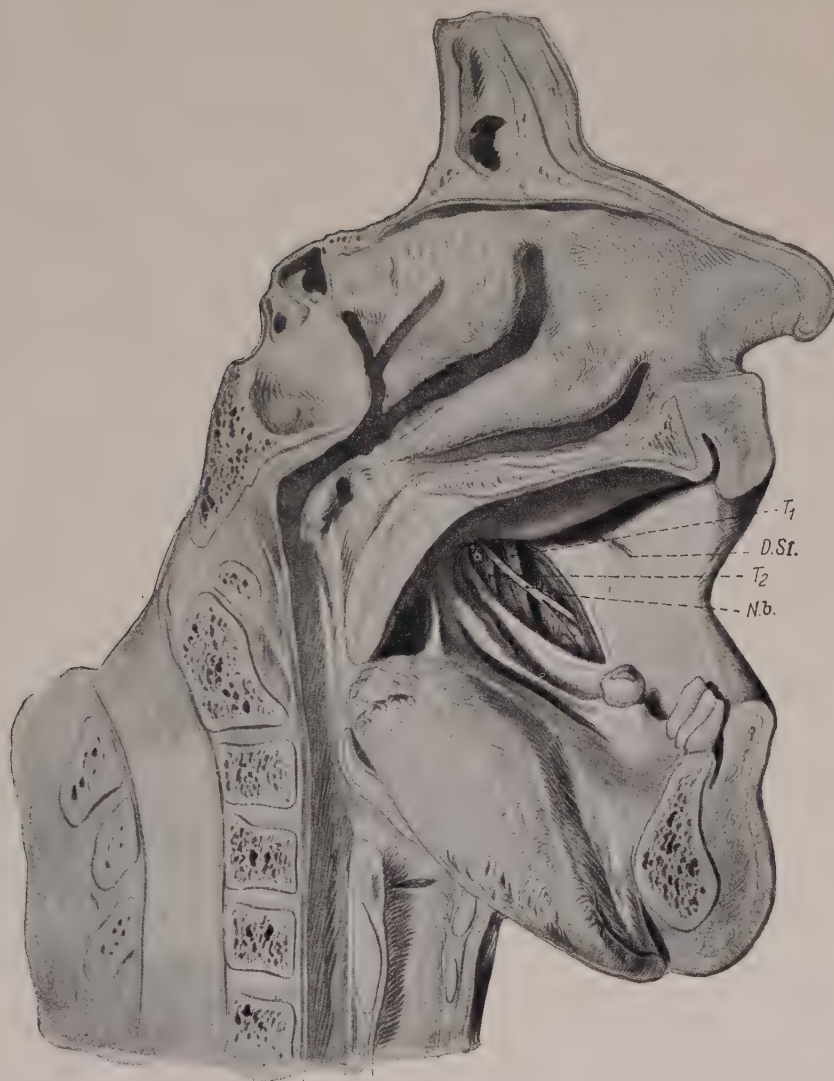
**Anesthesia of the Buccinator or Long Buccal Nerve.**—The mucosa of the mandible is supplied by several nerve fibers; the *inferior dental nerve* supplies a small area situated behind the third molar, its *mental branch* the buccal mucosa in the vicinity of the mental foramen. The *lingual nerve* supplies almost the entire lingual mucous covering of the mandible. The remaining area of buccal mucosa, extending from the second bicuspid to the third molar, is supplied by the *buccinator* or *long buccal nerve*. The extent of the buccinator zone, however, varies greatly; it may extend from the canine to the third molar, or may be limited to the area from the second bicuspid to the second molar. For complete absence of pain in the mandible, therefore, it is necessary to block this nerve also.

In surgical operations on one or three lower molars, infiltration of the buccal mucosa in addition to the mandibular injection is usually sufficient. In more extensive interventions, however, it is desirable to block the entire nerve trunk. This is achieved by injection in the posterior buccal portion of the mouth as determined by the distribution of the buccinator nerve.

The buccinator or long buccal nerve, being a branch of the third division of the trifacial nerve, in conjunction with the motor fibers supplying the temporal muscle passes forward and downward beneath or through the external pterygoid muscle to the inner surface of the tendon of the temporal muscle where this is inserted into the coronoid process. When the mouth is open the buccinator nerve crosses the anterior border of the ascending ramus at about the level of the masti-

cating surfaces of the upper molars, ramifies through the buccinator muscle to the mucosa of the cheek and sends its terminal fibers to the

FIG. 134



Exposure of long buccal nerve, shown by dissection of buccal mucosa and buccinator muscle. (Sicher.) *D. St.*, Probe introduced into orifice of Stenson's duct; *N. b.*, long buccal nerve; *T<sub>1</sub>*, superficial portion of temporal tendon inserted at anterior border of coronoid process; *T<sub>2</sub>*, deep portion of temporal tendon inserted at internal oblique line.

buccal alveolar mucosa (see Fig. 134). If we insert the needle in the mucosa of the cheek on a level with the masticating surfaces of the upper molars, slightly in front of the anterior border of the coronoid process, we reach the immediate vicinity of the nerve trunk, after piercing the thin plane of the buccinator muscle (see Fig. 134). Immediately after insertion of the needle we start injecting slowly and advance to from 0.5 to 1 cm., depositing 1 c.c. of a 2 per cent. solution. Anesthesia of the area of distribution of the buccinator nerve ensues within ten minutes, paresthesia occurring at the corner of the mouth similar to that observed in the chin and lip after mandibular injection.

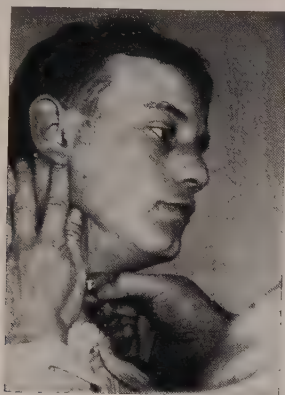
### EXTRA-ORAL BLOCKING OF THE MANDIBULAR NERVE.

In cases of severe trismus or extensive inflammation and swelling prohibiting intra-oral mandibular injection, the method of extra-oral injection at the foramen ovale is employed. The injection of from 3 to 5 c.c. of a 2 per cent. solution produces a profound and lasting anesthesia of an area, extending considerably beyond the limits of oral surgery proper, *viz.*, the temporal region to the vertex, the lower half of the cheek, the chin, the mandible, the angle of the mouth and the mandibular mucosa of the injected side. For dental purposes, therefore, this method should be selected only if all conditions are favorable for success without detriment to the patient. The modifications, as suggested by Peter Gadd, Klein and Sicher, Cieszynski and Kantorowicz are preferred in our work, being simpler and less risky.

If a line is drawn from the tragus to the anterior border of the masseter at the angle of the mandible, and this line is bisected, then the center marks the projection of the mandibular foramen upon the skin. The mandibular foramen is situated about 13 mm. from the posterior margin of the ascending ramus and 27 mm. from the angle (see Fig. 44). The foramen can be reached extraorally from behind or from below. Peckert suggests introducing the needle about 2 cm. above the angle over the posterior surface of the bone in an outward and forward direction until the mandibular sulcus is reached. At this point the ascending ramus is not covered with muscles and tendons,

but permits of unobstructed access (see Fig. 129). The mastoid process and the soft tissues, however, constitute a technical obstacle, so that this method has not become popular.

FIG. 135



Extra-oral injection at mandibular foramen, (After Klein and Sicher.) Right-side injection. The index finger and thumb fix the ascending ramus, angle and body of the mandible, as well as point of needle insertion. (Kantorowicz.)

FIG. 136

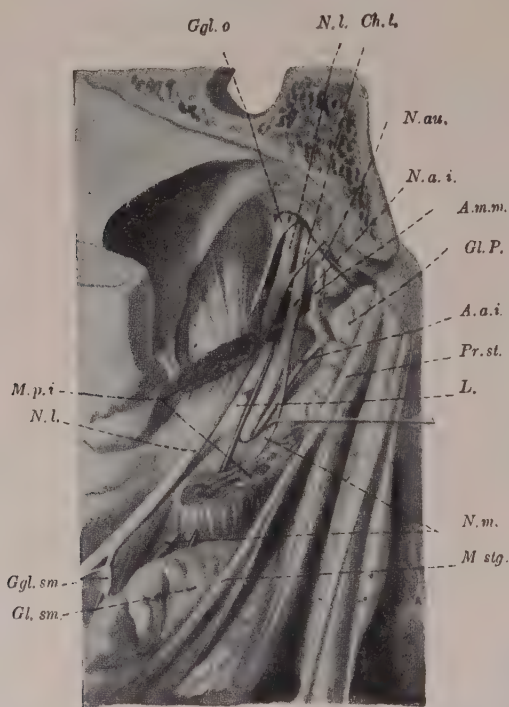


Anterior aspect of right-side injection. The needle is inserted anteriorly to the thumb nail. Needle directed outward. (Kantorowicz.)

The anatomic conditions are considerably more favorable at the inferior border of the body of the mandible. The injection is made

about 2 cm. from the angle, as first indicated by Peter Gadd. The needle advances from here upward and parallel to the posterior border of the ramus and mesially therefrom. The contour of the ascending ramus is fixed with the index finger, while the tip of the thumb rests

FIG. 137



Infratemporal region exposed after insertion of needle. A portion of the internal pterygoid muscle is resected to show entrance of the mandibular nerve into the mandibular canal. (Sicher.) *L.*, Lingula; *N. l.*, lingual nerve; *N. au.*, auriculotemporal nerve; *A. m. m.*, middle meningeal artery; *A. a. i.*, inferior dental artery; *N. m.*, mylohyoid nerve; *Ggl. o.*, otic ganglion; *Ch. t.*, chorda tympani nerve; *N. a. i.*, inferior dental nerve; *Gl. P.*, parotid gland; *Pr. st.*, stylohyoid process; *M. stg.*, styloglossus muscle.

upon the inferior border of the jaw (see Figs. 135 and 136). The mandibular sulcus is entered at a depth of from 4 to 5 cm. There is sufficient space for pushing the needle farther upward so as to reach the lingual nerve which lies above the inferior dental nerve (see Fig. 137). The best method of procedure is first to introduce the needle of from 6 to

7 cm. length to the desired depth, then to attach the Record syringe and to inject the solution. On the left side it is most practical for the operator to put his left arm around the patient's head, and to introduce the needle with the right hand while the left hand palpates and fixes the angle of the jaw from behind (see Fig. 138). The tip of the index finger overlaps the inferior border in front of the angle in the same manner as the thumb on the right side.

FIG. 138



Left-side injection. Thumb at posterior margin of the ascending ramus. Index finger palpating angle of mandible. (After Kantorowicz.)

It is important not to inject on the external, but the internal surface of the ascending ramus, and not to make the needle puncture too far mesially, else the internal oblique line is hit. If the insertion of the internal pterygoid muscle is abnormally developed resistance is soon met with; the needle is then withdrawn and again inserted in an altered direction. The anesthetic result is the same as with the intra-oral mandibular injection.

Klein and Sicher have justly emphasized that injury to vital organs or large bloodvessels, *viz.*, the external maxillary artery and the anterior facial vein, is out of the question. The internal maxillary artery is not reached, even if the needle is advanced higher up; hence,

anatomically speaking, the extra-oral method is no more hazardous than the customary intra-oral injection.

By way of recapitulation, it may be said that the extra-oral methods of blocking the second and third divisions of the trifacial nerve have proved their full justification and practicability. For the simple cases of daily dental practice, however, the intra-oral methods are amply sufficient. More complicated cases are best referred to the specialist. In all extensive operations, in phlegmon and purulent inflammations of the maxilla or mandible the extra-oral methods are indicated provided the operator possesses sufficient skill and experience, comprehensive knowledge of the anatomy of the field, and thorough appreciation of sterility of instrumentarium and solution. Without sufficient instruction, extra-oral injections should not be experimented with, since failures due to lack of knowledge and care may be of serious consequences to the patients entrusted to us. The injection at the foramen ovale is reserved for major surgery. A careful study of Figs. 109 to 116 will emphasize the great risk involved in extra-oral injections at the base of the cranium, and aid the operator in gauging the limits of his skill.

#### **RULES FOR CONDUCTION ANESTHESIA.**

1. Thorough sterilization of the field of the needle puncture.
2. Infiltration of the perineural tissue.
3. The fewer needle punctures, the better the result.
4. The bevel of the needle must always point toward the bone, and advance along the bone.
5. The solution is discharged under gentle pressure.
6. The intra-oral conduction anesthesia is best suited for daily practice, and should be the routine method of all dentists.
7. In difficult operations, severe phlegmon and extensive swelling, extra-oral injection is indicated. This hazardous method requires special knowledge and experience.
8. Waiting periods: In the maxilla, ten minutes; in the mandible, twenty minutes.
9. The patient must be kept under observation following injection.

### LOCAL ANESTHESIA IN CHILDREN.

The application of local anesthesia in children is directly proportionate to their age and mental development. Full mastery of technique is again the key to success which is considerably facilitated by the ready diffusion of the solution through the bony tissue of the young jaws.

The deciduous teeth in many cases can be anesthetized by infiltration if the child will keep still long enough for the somewhat dreaded needle puncture. Injection in the gum is best indicated. The needle is cautiously inserted buccally and lingually in the gum of the tooth anterior to the one to be anesthetized and slowly advanced along the alveolar ridge while discharging solution. The solution spreads readily, usually also to the palatal or lingual side. Marked anemia of the mucosa ensues. After a waiting period of from five to ten minutes, upper or lower teeth can be operated upon without pain. Another very efficient method consists in pushing the needle through the interdental papilla to the alveolar septum where the bulk of solution is deposited.

Blocking of the mandibular nerve can be employed in children of four years of age. Whenever possible, it should be used for anesthesia of the permanent teeth. In purulent conditions ethyl chlorid anesthesia is preferable.

Owing to the rapid metabolism in children, the elimination of an injected solution generally takes place more readily and with less irritation than in adults. The quantity of solution applicable in children always suffices to produce a profound and extensive anesthesia. In our experience, even frail children easily tolerate from 6 to 8 c.c. of a 2 per cent. solution, regardless as to whether conduction or infiltration anesthesia is employed.

Frail, sickly or undernourished children have a tendency to faint after injection. In these, prophylactic doses of 5 drops of camphorated validol with a little water are indicated, and the injection should be made very slowly. It is also advisable to reduce the concentration of the solution to 1.5 per cent. The operator's psychic control over

the child is of great importance. If properly manipulated the child in his curiosity will not mind the first needle puncture, upon which depends the success of any subsequent operation. The tactful assistance of a female nurse will also help in calming the young patient. If the first needle puncture and partial injection of solution have been accomplished without resistance, further infiltration of the deeper tissue strata is easy. Once complete anesthesia has been obtained in a child, his fear of the dentist will be forever eliminated.

**Extent of Local Anesthesia in the Maxillæ.**—The action of local anesthetics in the healthy organism can be traced step by step, especially with the aid of the electric current.

Infiltration of an upper central incisor notably diminishes the sensibility of the pulp in two minutes; after five minutes complete anesthesia is established. This condition of complete anesthesia usually lasts from twenty to twenty-five minutes. It is noteworthy that, even during this state of complete anesthesia, strong electric currents still exert an influence upon the eye, producing a slight scintillation as well as lacrimal secretion, owing to the relationship between the first and second divisions of the trigeminal nerve. After about seventy minutes, counting from the beginning of the injection, normal conditions return.

After injection at the maxillary tuberosity and at the posterior palatine foramen, sensibility is reduced in the molars within two minutes; after five minutes the bicuspid and the canine also exhibits reduced sensibility. After three additional minutes the buccal mucous membrane is entirely insensible, while the lip seems still to react normally. Within ten minutes, complete anesthesia is established in the molars, lasting for about thirty minutes then gradually subsiding. The sensibility of the bicuspid and canines is notably reduced. Within from forty to sixty minutes normal sensibility is reestablished in the teeth, while the mucosa, especially in the vicinity of the maxillary tuberosity, is still completely anesthetized.

The prompt effect of injection at the maxillary tuberosity was demonstrated in a highly sensitive and seriously neurotic woman. Anesthesia of the second upper bicuspid with an inflamed pulp was

accompanied by the following symptoms: After two minutes light anesthesia set in in all molars and bicuspid of the injected side. After three minutes the teeth, which had been extremely sensitive to a light current, tolerated a current of double; after five minutes, one of triple strength. After fourteen minutes complete anesthesia was established. The pulp of the second bicuspid was amputated to the root canals without any pain whatever. For the sake of experiment, the strong current was applied to the amputated pulp stumps. It was surprising to note a very faint reflex. Nevertheless the root portions of the pulp were immediately extirpated without any pain whatever, contrary to expectation. The mechanical irritation incidental to extirpation of the pulp evidently produced no pain, while the electric irritation was still perceived, presumably because, in contradistinction to the irritation from localized pressure, it was conveyed by the cells to remote areas of sensation. After twenty-six minutes the anesthesia began to wear off.

Infraorbital injection produces a pronounced anesthesia of the mucous and muscular layers, characterized by a reduction in sensibility within one minute. The anterior teeth are completely anesthetized after ten minutes, sensibility gradually returning after thirty minutes.

The effect of mucous anesthesia in the mandible appears to be rather uncertain. This form of anesthesia was tested out in a lower first bicuspid affected with pulpitis; the sensibility of the pulp was not reduced notably, even after eight minutes. A mandibular injection was then given, which considerably reduced the sensibility of the inflamed pulp, complete anesthesia ensuing within fourteen minutes from the beginning of the experiment.

Mandibular injection will produce anesthesia of the mouth and the mucosa of the lip within three minutes. After four minutes tingling in the lip and in the corresponding half of the tongue is perceived. The tongue gradually grows heavier, and the numbness of the lip spreads to the other side. After ten minutes the teeth on one side of the mandible are insensible, and within twenty minutes the entire half of the jaw is anesthetized. Complete anesthesia with

all its symptoms persists for thirty minutes, after which time it gradually subsides. The central incisors are the first to regain sensitivity, sensation in the other teeth returning in rapid succession. The tongue

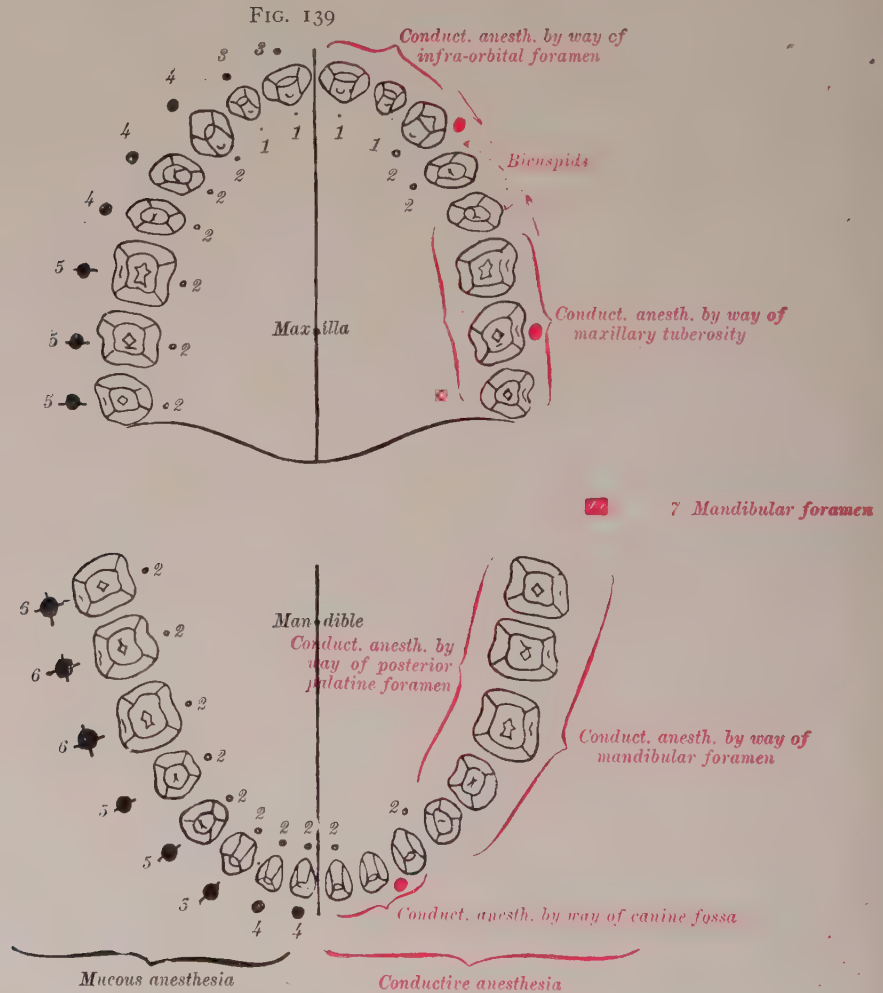


Diagram illustrating the technique and dosage for local injection. On the left, black figures indicate technique and dosage for mucous anesthesia. On the right, red figures indicate technique and dosage for conductive anesthesia. Dosage: 1 = about 10 drops; 2 = 0.25 c.c.; 3 = 0.5 c.c.; 4 = 1 c.c.; 5 = 1.25 c.c.; 6 = 1.5 c.c.; 7 = 2 c.c.

becomes normal after ninety minutes, while the mucosa remains insensible for two hours. Normal sensation is not reëstablished until three hours after injection.

### TABLES FOR INJECTION ANESTHESIA.

In order to avoid repetitions such as histories of practical cases would entail, yet in order to offer a practical working scheme for the application of the methods described, tables are here presented which indicate the method of injection best suited for each tooth. The special requirements of a case may, of course, call for modifications of these tables, which are intended as a general guide to those who wish to become expert in this somewhat difficult technique.

*Periods of Waiting.*—The period of waiting in the cases Nos. 1 to 4 and 9 to 10 is about ten minutes; in Nos. 5 to 8, fifteen minutes; in Nos. 11 to 16, twenty minutes. In Nos. 12 to 16 no injection linguallly is required. Modifications or combinations for the anesthetization of several teeth on one side can easily be deduced from these tables.

## TECHNIQUE OF LOCAL ANESTHESIA

| Teeth.<br>I. UPPER. | Technique of injection employed.                                                                                                     |                                                                                                                                                                                                                                                                                                                                           | Mountings<br>of<br>syringe.                                  | Quantity of solution.                              |                                         |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|----------------------------------------------------|-----------------------------------------|
|                     | (a) In simple cases.                                                                                                                 | (b) In cases complicated<br>by periostitis, parulis,<br>abscess, etc.                                                                                                                                                                                                                                                                     |                                                              | In labial or<br>buccal<br>injections.              | In palatal<br>or lingual<br>injections. |
| 1. Central incisors | Needle inserted at middle of root of lateral, and advanced to root apex of central; palatally, injection at central                  | Needle inserted at middle of roots of canine of same, and central of opposite side, whose root apices are infiltrated with solution; palatally, injections at lateral of same, and central of opposite side; or conduction anesthesia at infra-orbital foramen, and mucous anesthesia at central of opposite side, palatally and labially | Hub B, needle No. 1; for conduction anesthesia, needle No. 2 | In cases of class.<br>(a) 1.5 c.c.<br>(b) 2.5 c.c. | (a) 0.5 c.c.<br>(b) 0.5 c.c.            |
| 2. Lateral incisors | Needle inserted at middle of root of canine, and advanced to root apex of lateral; palatally, injection at lateral                   | Needle inserted back of root apex of canine, where solution is deposited; same procedure at root apex of central; palatally, injection at lateral, or at central and canine                                                                                                                                                               | As in 1                                                      | As in 1                                            | As in 1                                 |
| 3. Canines          | Needle inserted at root apex of canine, where solution is deposited; palatally, injection at canine                                  | Conduction anesthesia at infraorbital foramen; palatally, injection at canine, or first bicuspid and lateral                                                                                                                                                                                                                              | (a) As in 1<br>(b) Long needle                               | (a) 1.5 c.c.<br>(b) 2.5 c.c.                       | (a) 0.5 c.c.<br>(b) 0.5 c.c.            |
| 4. First bicuspid   | Needle inserted at middle of root of canine, and advanced to root apex of first bicuspid; palatally, injection at first bicuspid     | Injection at maxillary tuberosity and in canine fossa; palatally, injection at posterior palatine foramen                                                                                                                                                                                                                                 | As in 3                                                      | 2 to 4 c.c.                                        | 0.5 c.c.                                |
| 5. Second bicuspid  | Needle inserted at middle of root of first bicuspid and advanced to root of second bicuspid; palatally, injection at second bicuspid | Injection at maxillary tuberosity and in canine fossa; palatally, injection at posterior palatine foramen                                                                                                                                                                                                                                 | As in 4                                                      | As in 4                                            | As in 4.                                |
| 6. First molars     | Injection at maxillary tuberosity and posterior palatine foramen                                                                     | Injection at maxillary tuberosity and posterior palatine foramen                                                                                                                                                                                                                                                                          | Long needle                                                  | As in 4                                            | As in 4.                                |
| 7. Second molars    | Injection at maxillary tuberosity and posterior palatine foramen                                                                     | Injection at maxillary tuberosity and posterior palatine foramen                                                                                                                                                                                                                                                                          | As in 6                                                      | As in 4                                            | As in 4.                                |
| 8. Third molars     | Injection at maxillary tuberosity and posterior palatine foramen                                                                     | Injection at maxillary tuberosity and posterior palatine foramen                                                                                                                                                                                                                                                                          | As in 6                                                      | As in 4.                                           | As in 4.                                |

| Teeth.<br>II. LOWER.    | Technique of injection employed.                                                                                                                                                                                                       |                                                                                                                                                                             | Mountings<br>of<br>syringe.           | Quantity of solution.                        |                                        |
|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|----------------------------------------------|----------------------------------------|
|                         | (a) In simple cases.                                                                                                                                                                                                                   | (b) In cases complicated<br>by periostitis, parulis,<br>abscess, etc.                                                                                                       |                                       | In labial or<br>buccal<br>injections.        | In palatal<br>or lingual<br>injections |
| 9. Central<br>incisors  | Needle inserted at mid-<br>dle of root of lateral<br>and advanced to root<br>apex of central; lin-<br>gually, injection at<br>central                                                                                                  | Needle inserted in re-<br>flection of mucous<br>membrane below can-<br>ine and advanced to<br>mental fossa, where<br>solution is deposited<br>or mandibular injec-<br>tion  | Hub B and<br>needle<br>Nos. 2 or<br>3 | (a) 1.0 to<br>2 c.c.<br>(b) 1.5 to<br>2 c.c. | 0.5 c.c.                               |
| 10. Lateral<br>incisors | Needle inserted at mid-<br>dle of root of canine,<br>and advanced to lat-<br>eral; lingually, injec-<br>tion at lateral                                                                                                                | Needle inserted in re-<br>flection of mucous<br>membrane below can-<br>ine, and advanced to<br>mental fossa, where<br>solution is deposited<br>or mandibular injec-<br>tion | As in 9                               | As in 9                                      | As in 9                                |
| 11. Canines             | Needle inserted in re-<br>flection of mucous<br>membrane below can-<br>ine, and advanced to<br>mental fossa, where<br>solution is deposited;<br>lingually, injection at<br>canine or first bicus-<br>pid, or mandibular in-<br>jection | Needle inserted in re-<br>flection of mucous<br>membrane below can-<br>ine, and advanced to<br>mental fossa, where<br>solution is deposited;<br>mandibular injection        | As in 9                               | As in 9                                      | As in 9                                |
| 12. First<br>bicuspid   | Mandibular and bucci-<br>nator injections                                                                                                                                                                                              | Mandibular and bucci-<br>nator injections                                                                                                                                   | As in 9                               | 1 to 2 c.c.                                  |                                        |
| 13. Second<br>bicuspid  | Mandibular and bucci-<br>nator injections                                                                                                                                                                                              | Mandibular and bucci-<br>nator injections                                                                                                                                   | As in 9                               | As in 12                                     |                                        |
| 14. First<br>molars     | Mandibular and bucci-<br>nator injections                                                                                                                                                                                              | Mandibular and bucci-<br>nator injections                                                                                                                                   | As in 9                               | As in 12                                     |                                        |
| 15. Second<br>molars    | Mandibular and bucci-<br>nator injections                                                                                                                                                                                              | Mandibular and bucci-<br>nator injections                                                                                                                                   | As in 9                               | As in 12                                     |                                        |
| 16. Third<br>molars     | Mandibular and bucci-<br>nator injections                                                                                                                                                                                              | Mandibular and bucci-<br>nator injections                                                                                                                                   | As in 9                               | As in 12                                     |                                        |

DISTRIBUTION OF THE SENSORY BRANCHES OF THE TRIFACIAL NERVE.  
(AFTER HAERTEL.)

|                  |   |                                    |   |                                                                               |   |                                                                    |
|------------------|---|------------------------------------|---|-------------------------------------------------------------------------------|---|--------------------------------------------------------------------|
| Maxillary nerve  | { | Posterior-superior alveolar nerves | { | Middle-and anterior-superior alveolar nerves                                  | { | Upper teeth and buccal gingiva.                                    |
|                  |   | Infraorbital nerve                 |   | Superior labial branch                                                        |   | Mucosa of the upper lip.                                           |
|                  | { | Sphenopalatine ganglion            | { | Nasopalatine nerve<br>Palatine nerves                                         | { | Palatal periosteum and gingiva, hard and soft palate.              |
| Mandibular nerve | { | Inferior dental nerve              | { | Dental branches<br>Mental nerve                                               | { | Lower teeth and gingiva.<br>Mucosa of the lower lip.               |
|                  |   | Lingual nerve                      |   | Sublingual nerve<br>Lingual branches<br>Branches to the isthmus of the fauces |   | Lingual gingiva of anterior teeth.<br>Tongue to the foramen cecum. |
|                  | { | Buccinator nerve                   | { |                                                                               | { | Mucosa of the cheek.<br>Buccal gingiva of molars.                  |
|                  |   |                                    |   |                                                                               |   |                                                                    |

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